ΠΑΝΕΠΙΣΤΗΜΙΟ ΘΕΣΣΑΛΙΑΣ
ΤΜΗΜΑ ΕΠΙΣΤΗΜΗΣ ΦΥΣΙΚΗΣ ΑΓΩΓΗΣ ΚΑΙ ΑΘΛΗΤΙΣΜΟΥ

ΕΠΕΑΕΚ 2
MANAGING AUTHORITY OF THE OPERATIONAL PROGRAMME EDUCATION AND INITIAL VOCATIONAL TRAINING

EUROPEAN COMMUNITY
Co financing
European Social Fund (E.S.F.)
European Regional Development Fund (E.R.D.F.)

MINISTRY OF NATIONAL EDUCATION AND RELIGIOUS AFFAIRS

Νέες Τεχνολογίες στην Ανάλυση της Κίνησης

Διάλεξη 1
Σφάλμα – Ανάλυση χρόνου και συχνοτήτων – Εξομάλυνση δεδομένων

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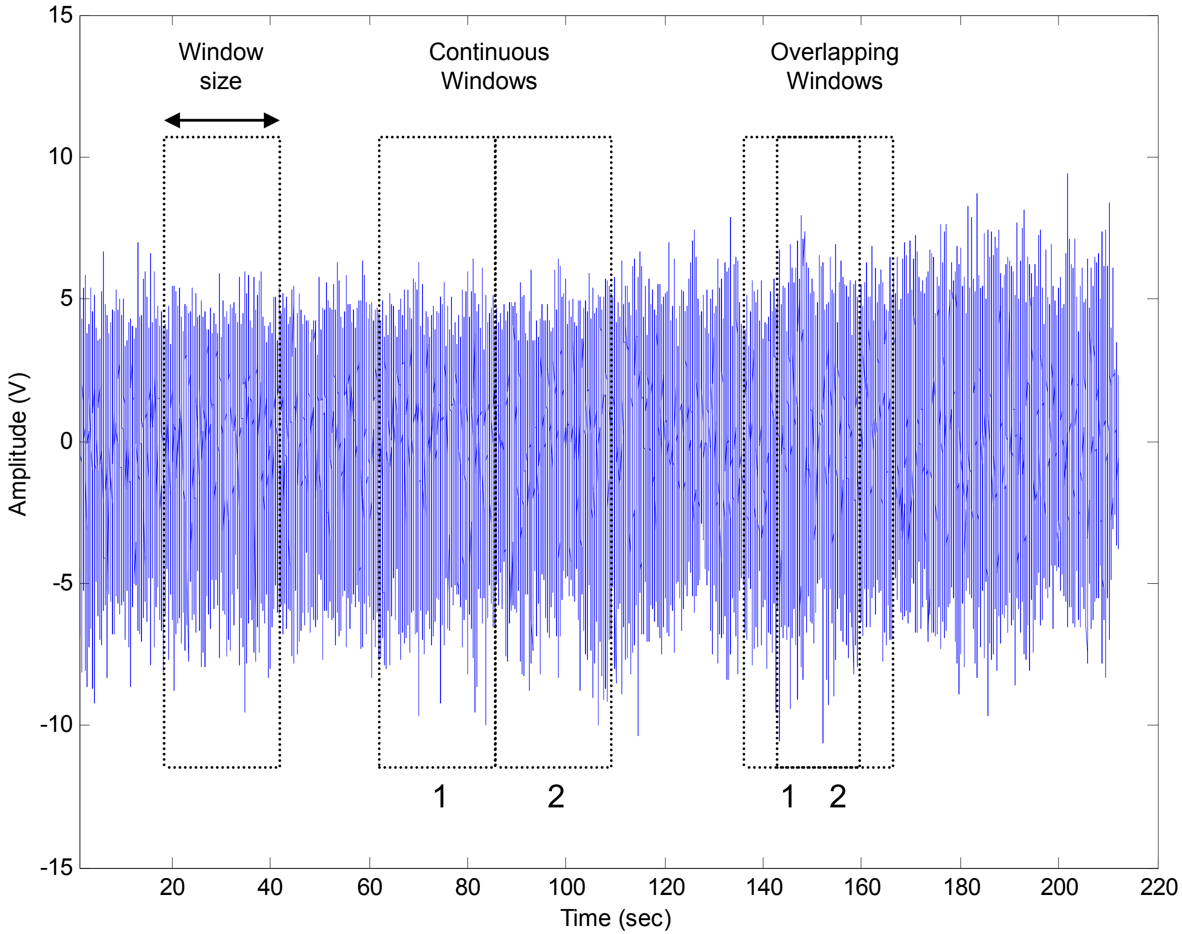
ggiakas@pe.uth.gr

Presentation Outline

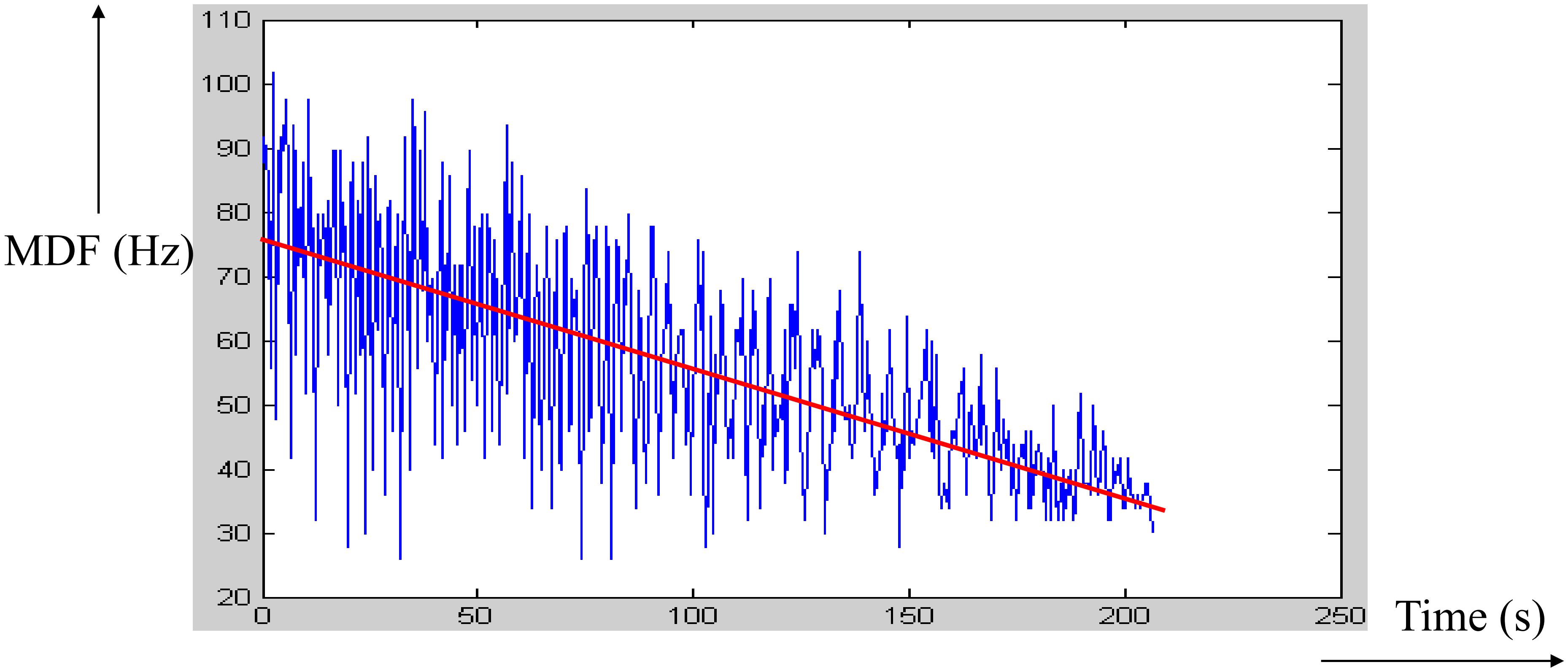
- Background – Problems
- Solutions
- Current / future research


TO FIRE EXIT

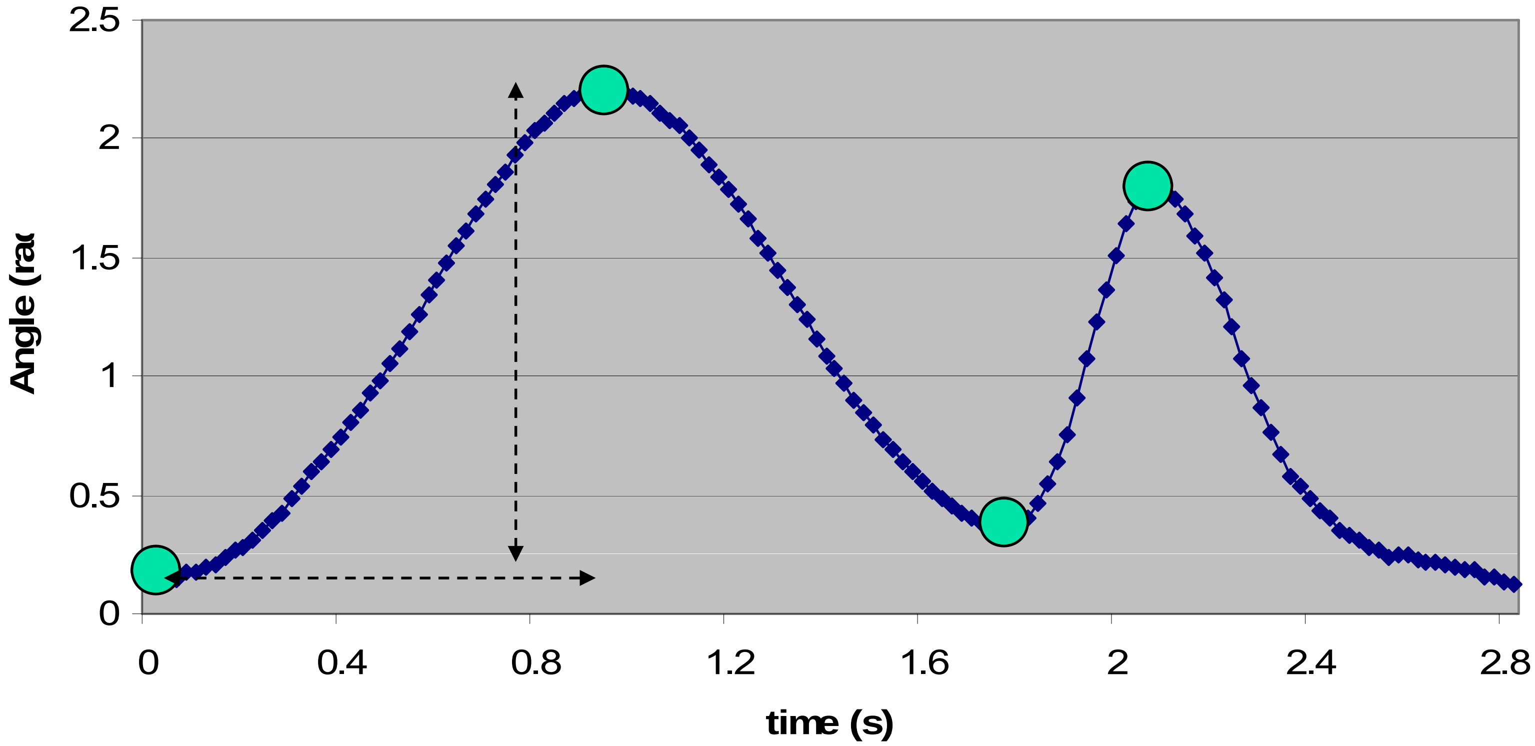
Signal analysis



Signal analysis



Signal analysis



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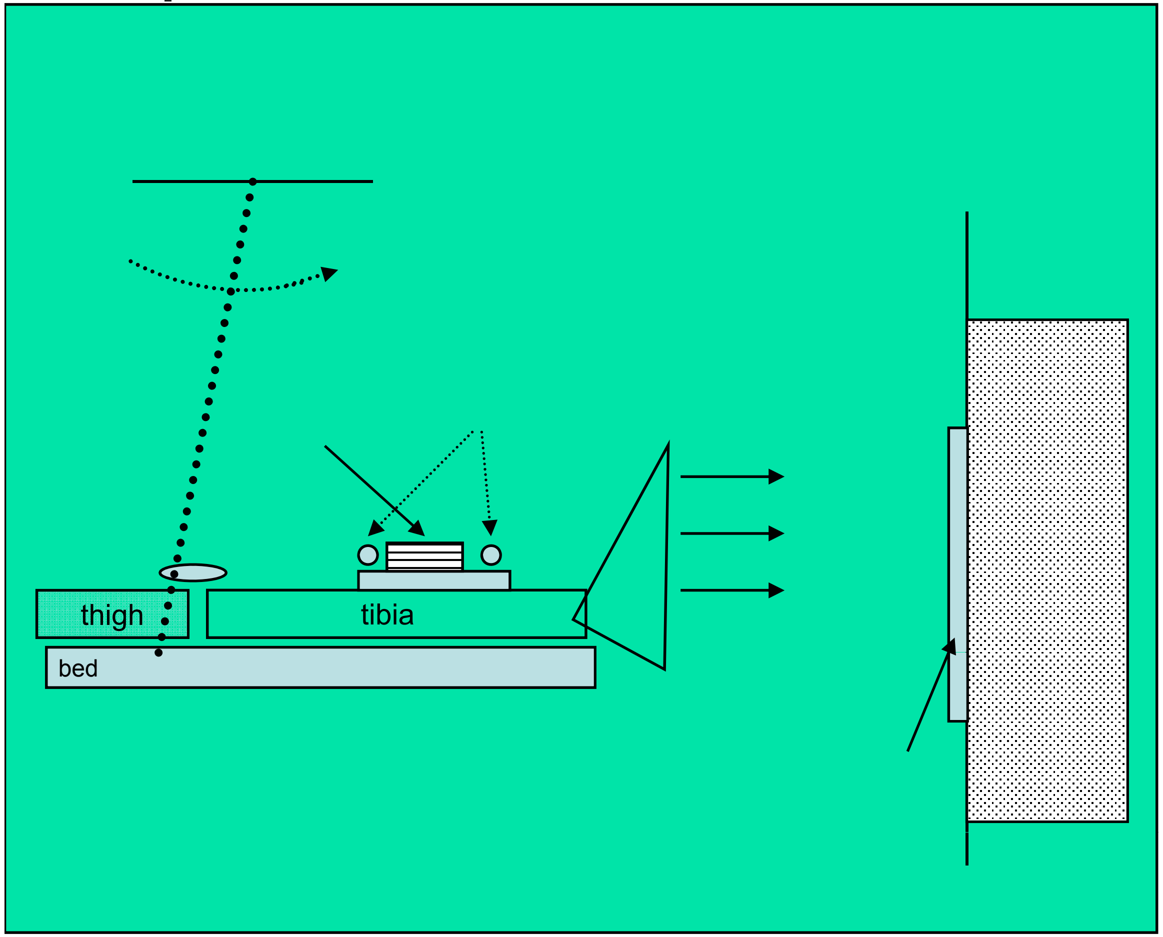
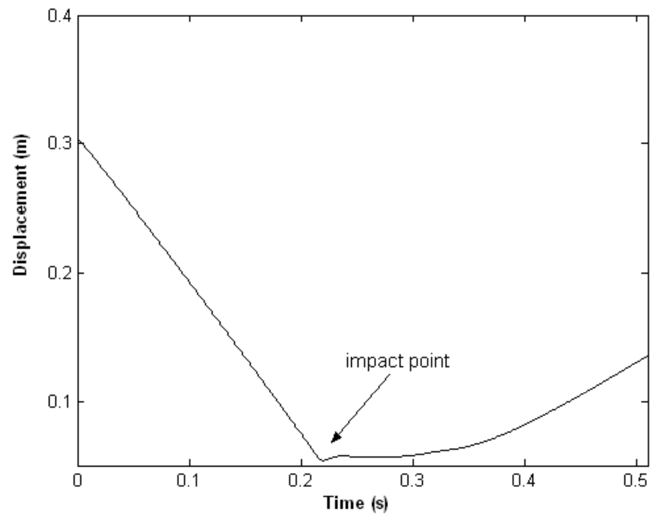
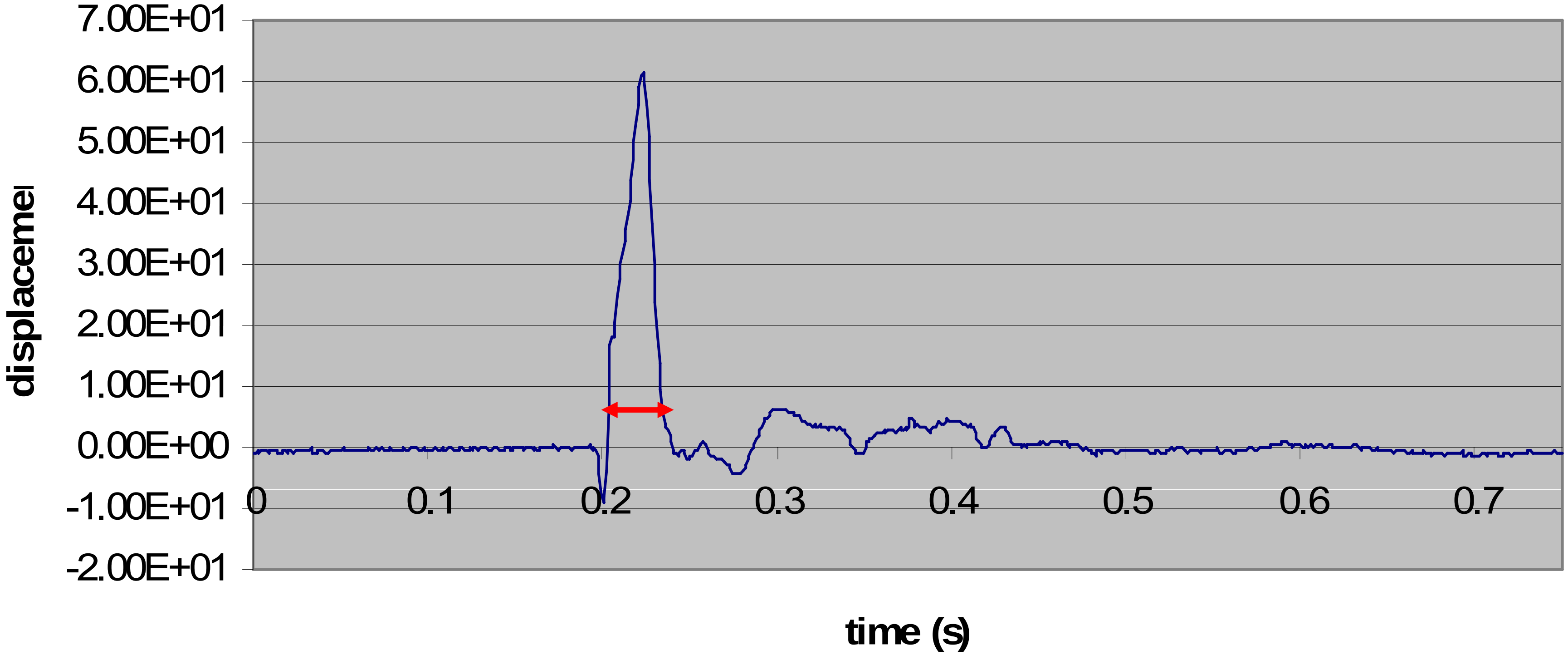
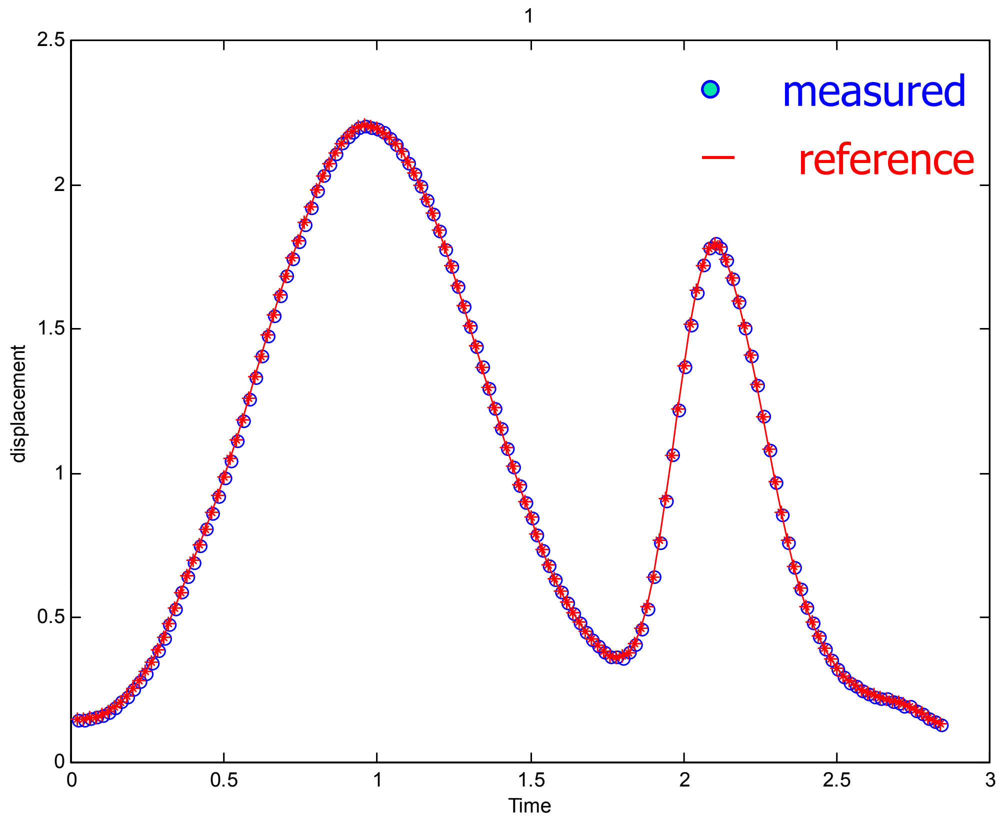




Signal analysis



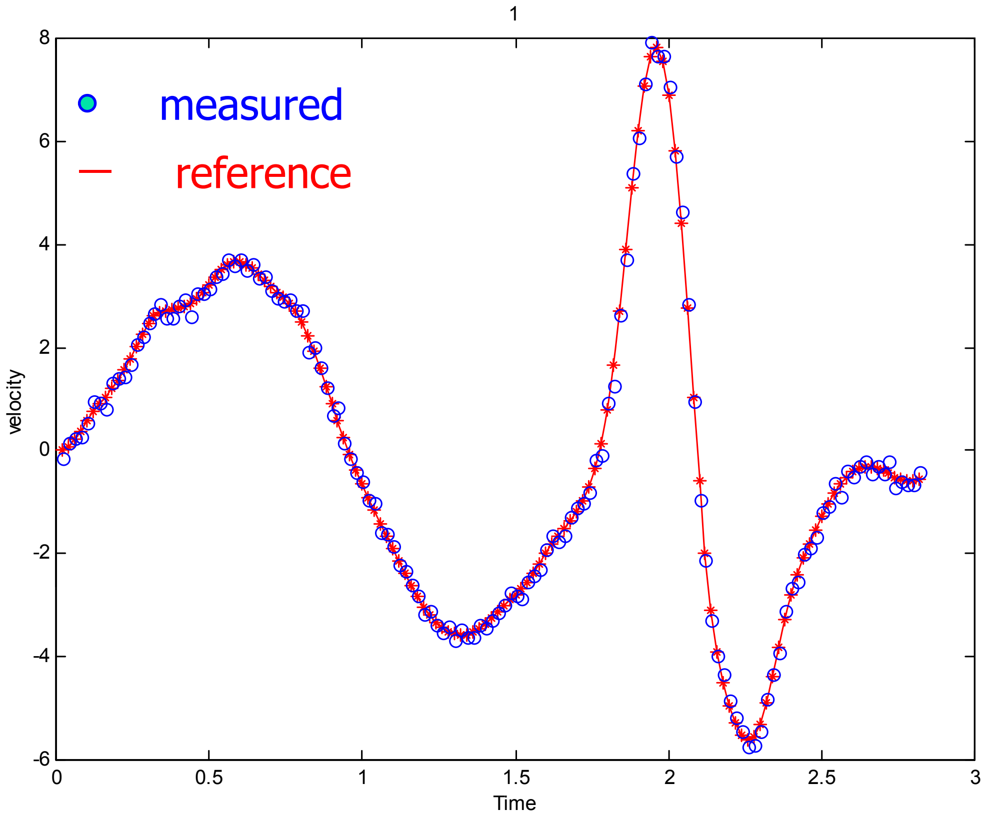
The effect of error : displacement



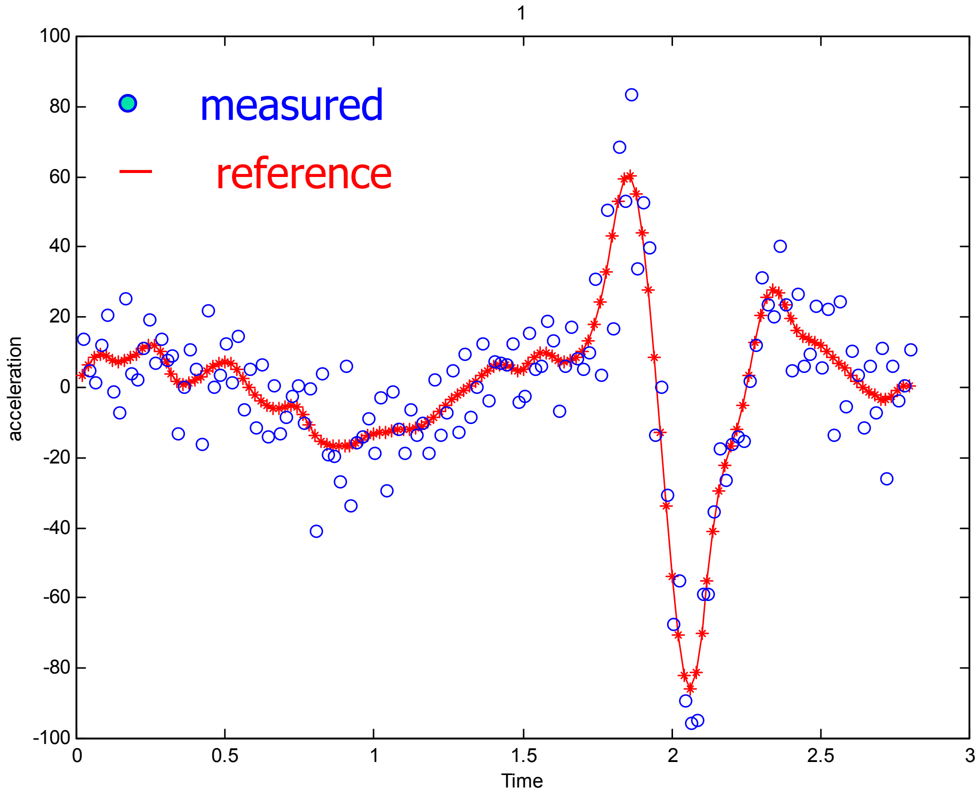
Pezzack, 1977; Lanshammar, 1982

- Velocity = displacement / time
  - Velocity = DER(Displacement)
- Acceleration = velocity / time
  - Acceleration = DER (Velocity) = DER_DER(Displacement)

The effect of error : velocity

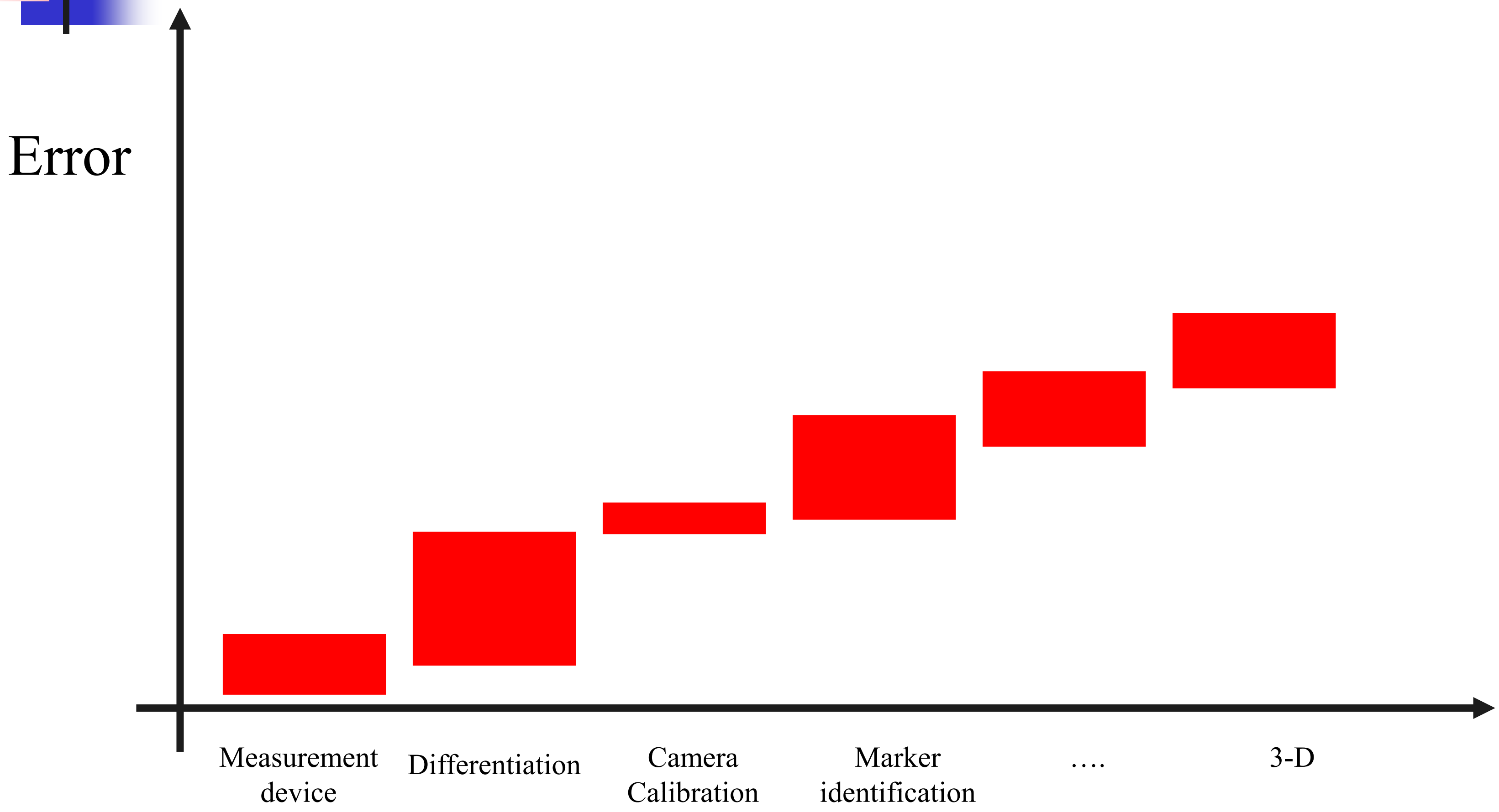


The effect of error : acceleration



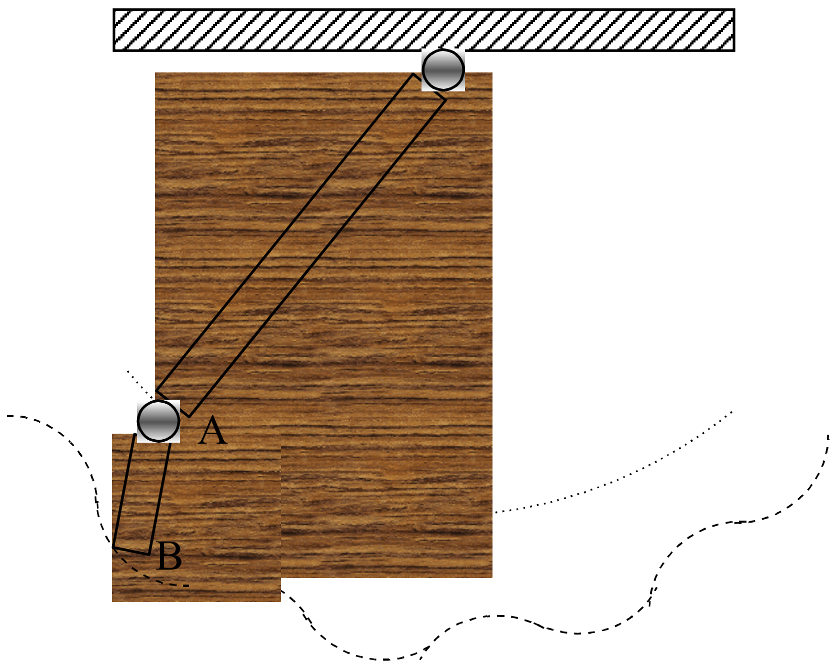
Reference acceleration provided by Graeme Wood, 1997

Sources of error

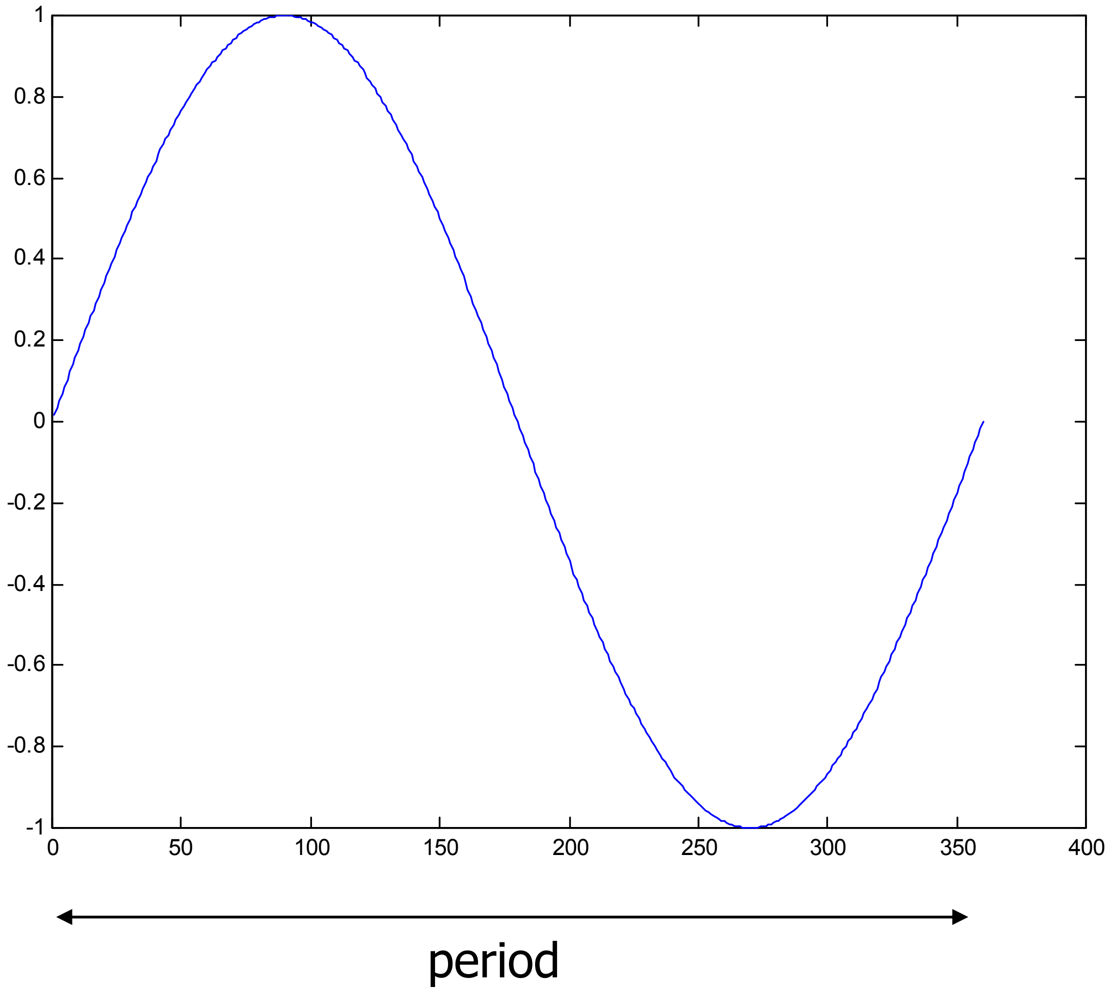


Why is this happening ?

- Frequency domain analysis



1*Sin(1x)



1
0.8
0.6
0.4
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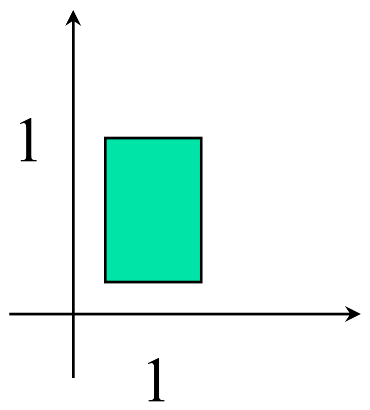
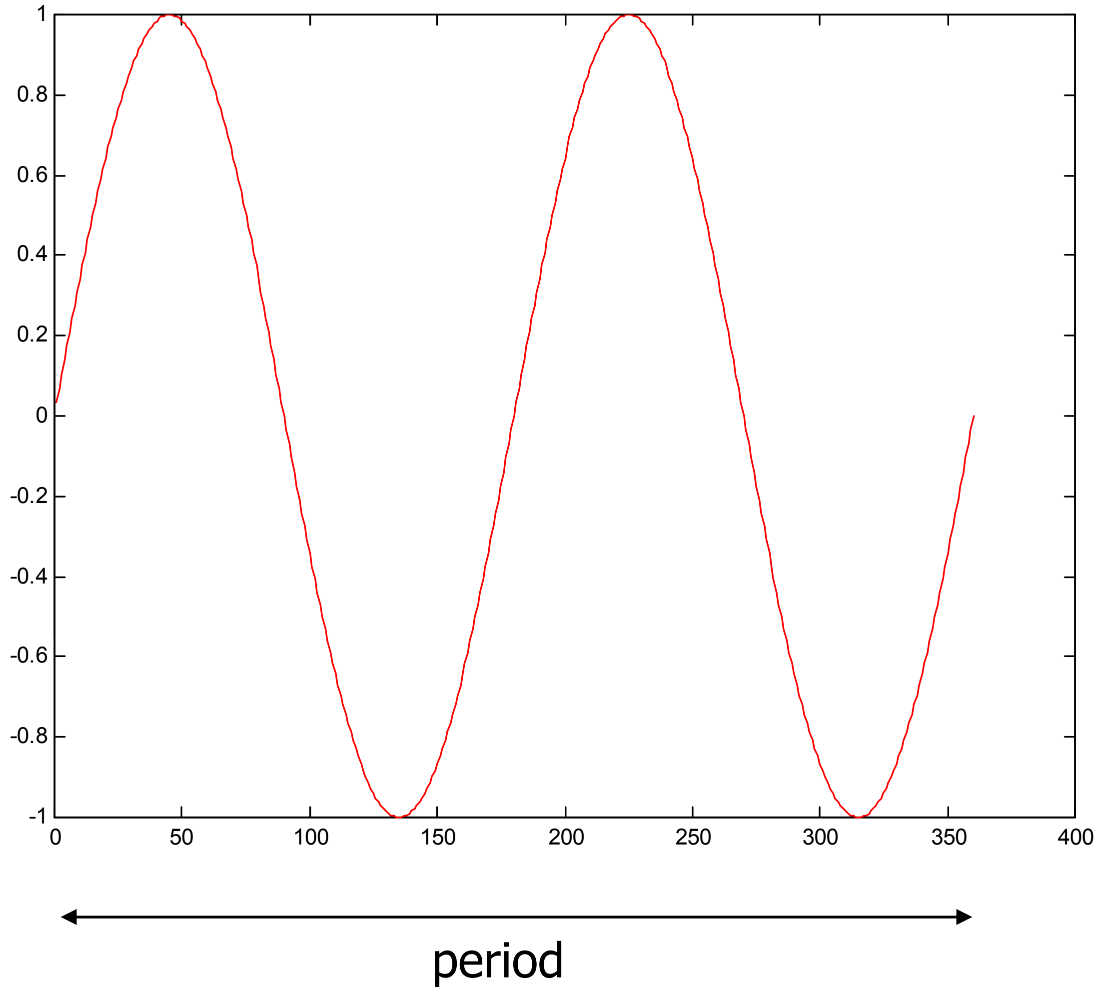
250
300
350
400
period



1
1

1*Sin(2x)



1
0.8
0.6
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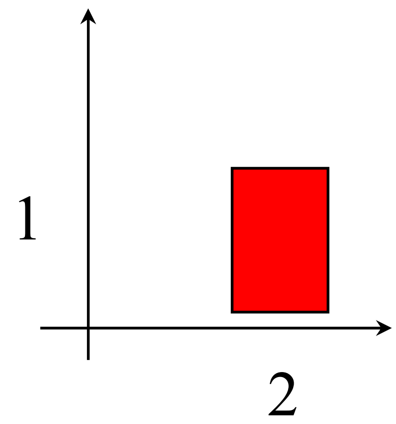
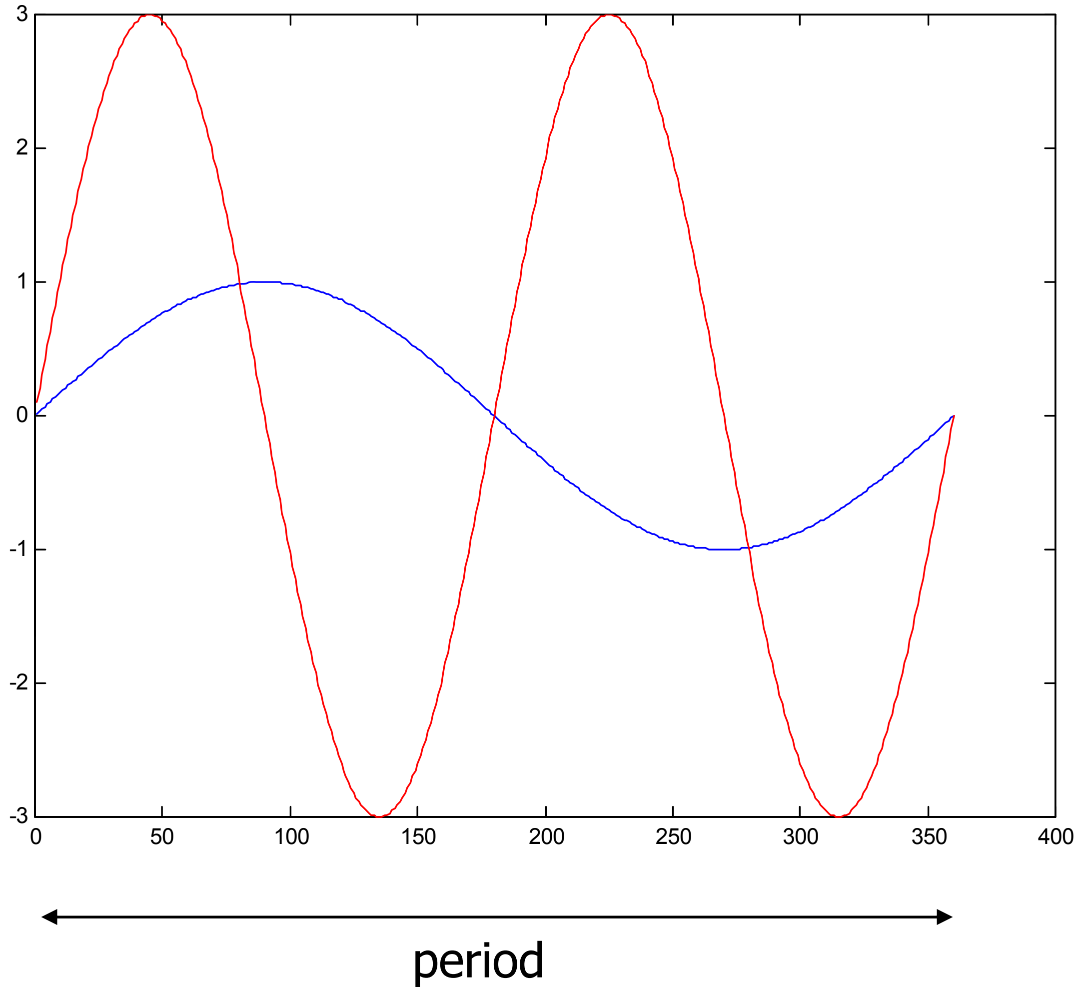
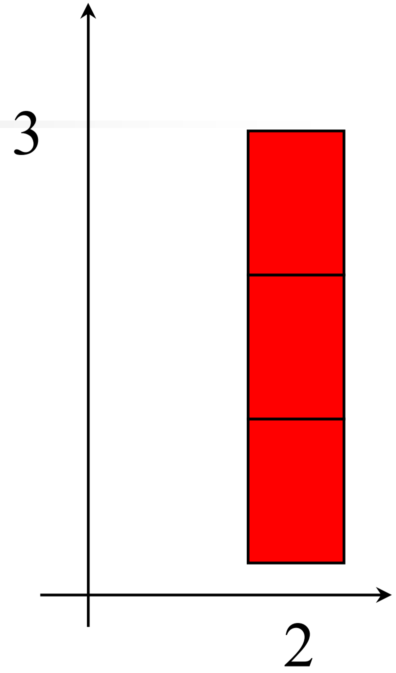
period

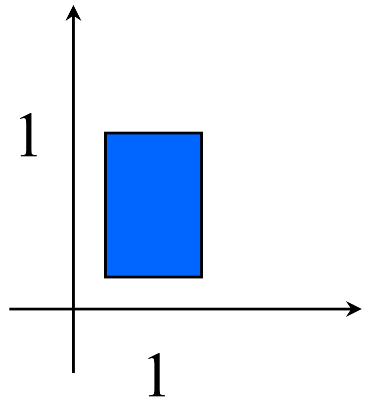


1
2

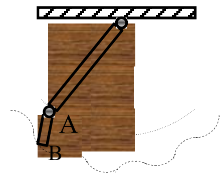
Sin(x) ----- 3*Sin(2x)

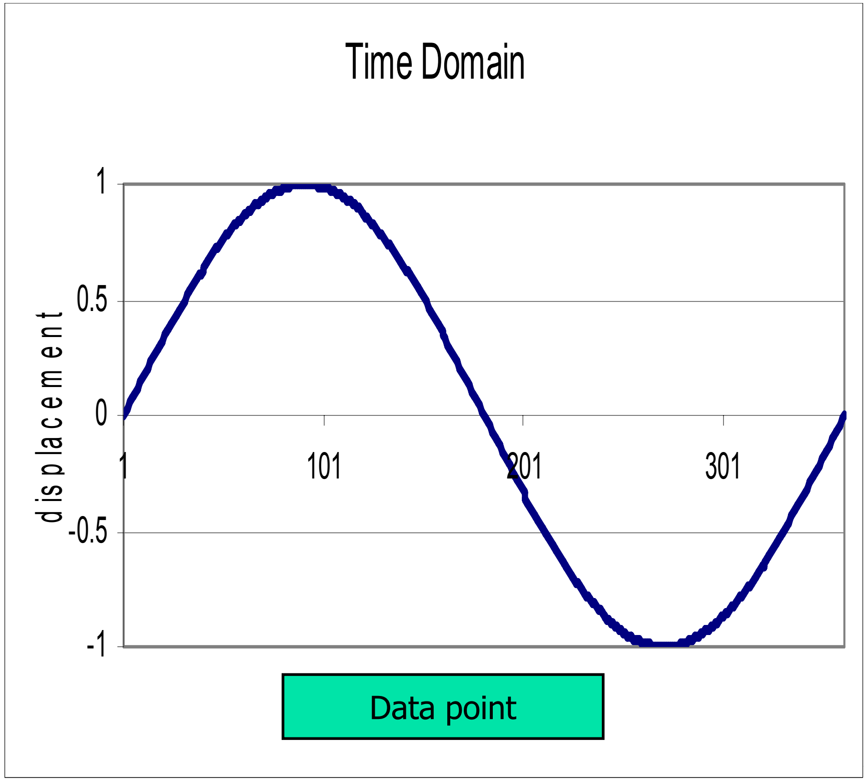


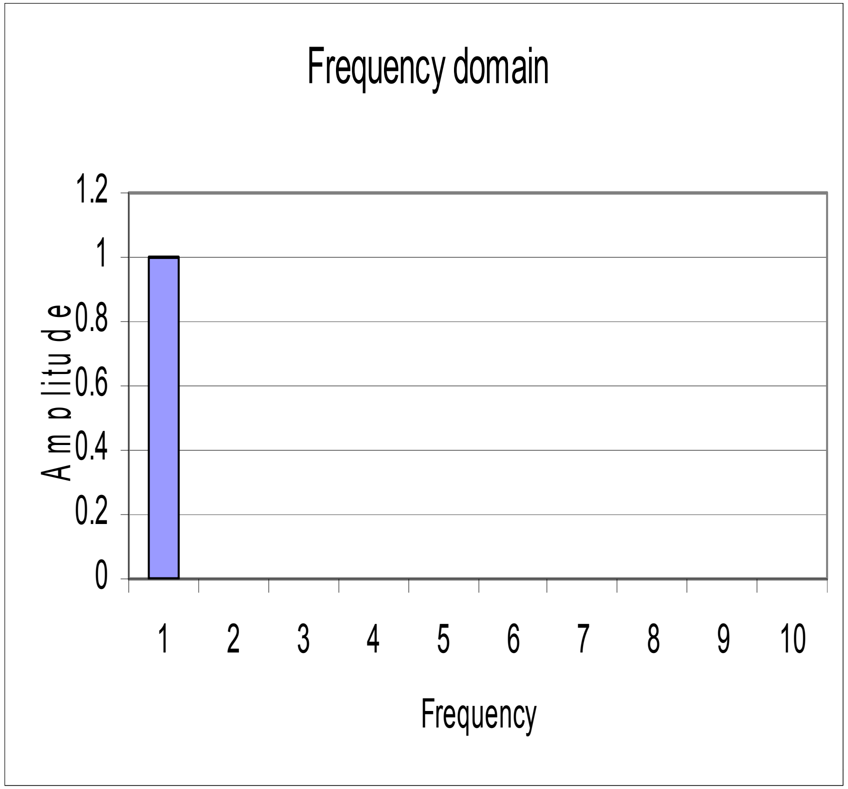


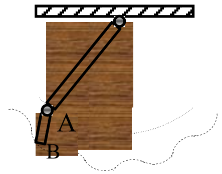


Time domain - Frequency domain

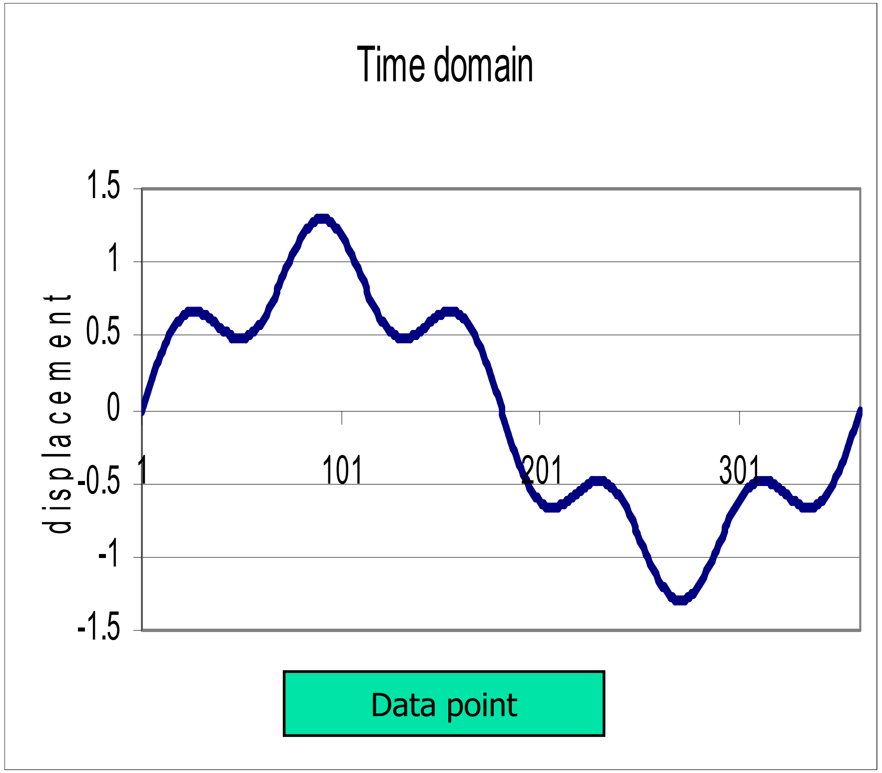


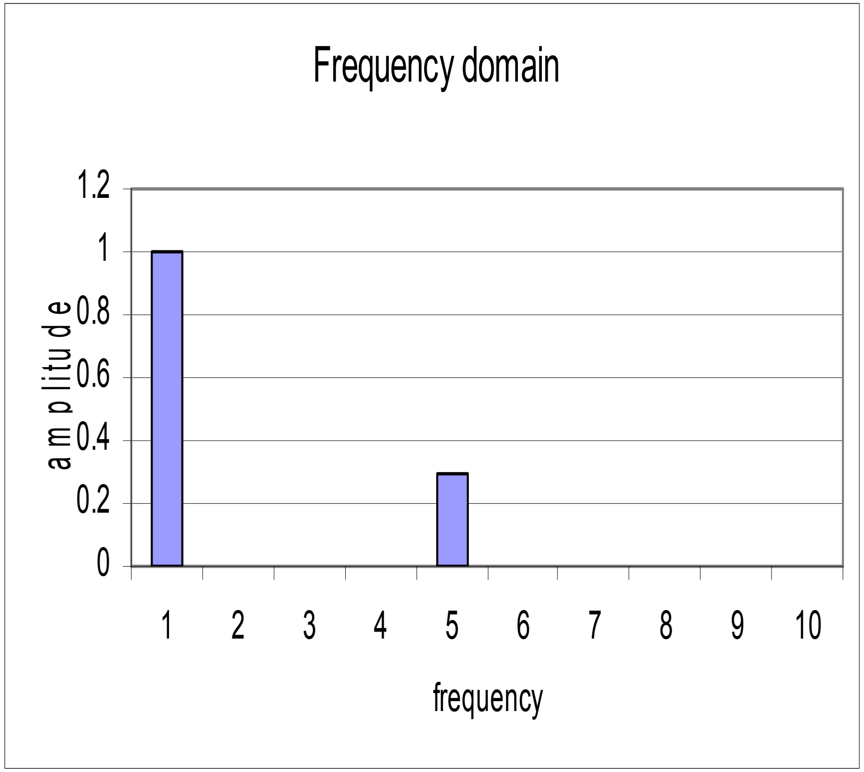






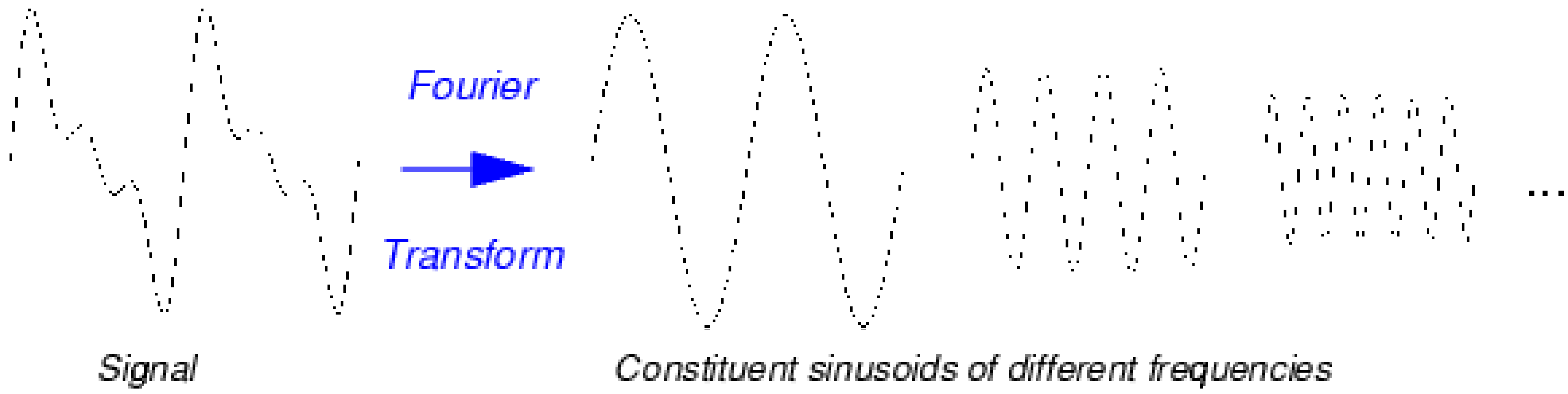
Time domain - Frequency domain





Time domain - frequency domain (Fourier Transform)

$$\text{Signal} = \sum [a\text{Sin}x + b\text{Cos}x] + c$$



Four essential components of time-varying signal

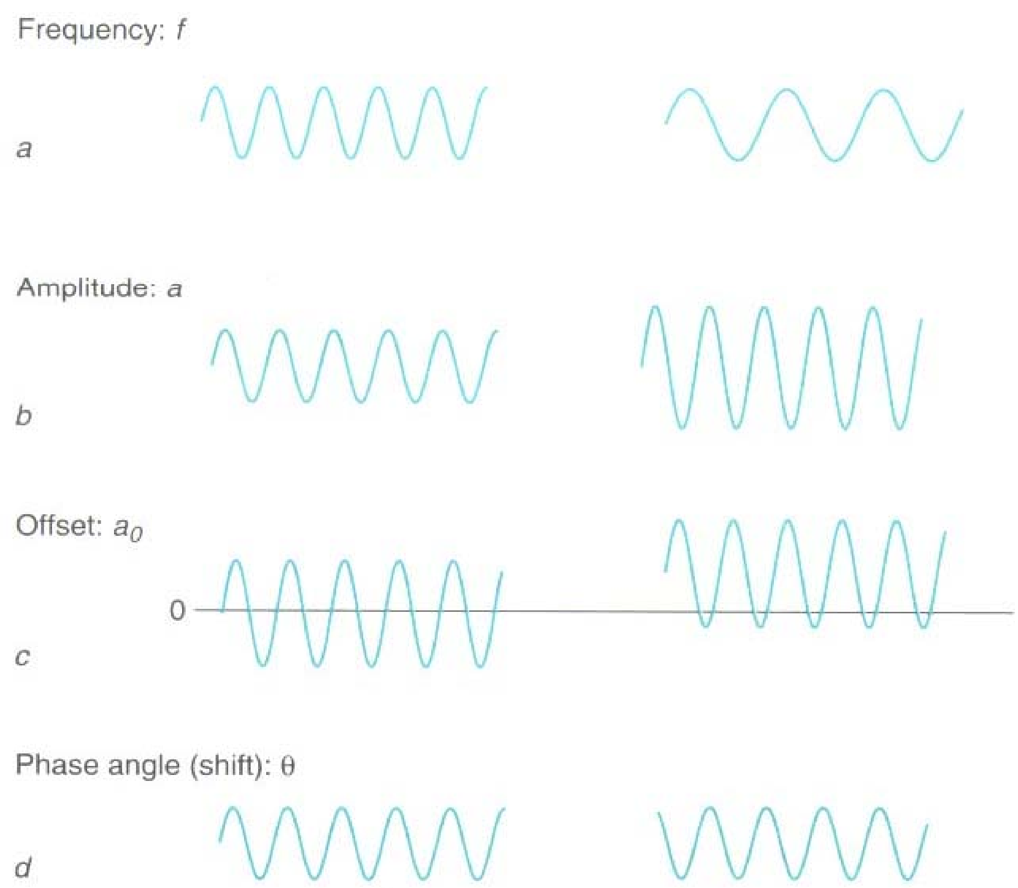


Figure 11.2 The four essential components of a time-varying signal.

Higher derivatives

- Velocity and acceleration

- Any error included in the displacement data will significantly be amplified via the differentiation process (ill posed problem)

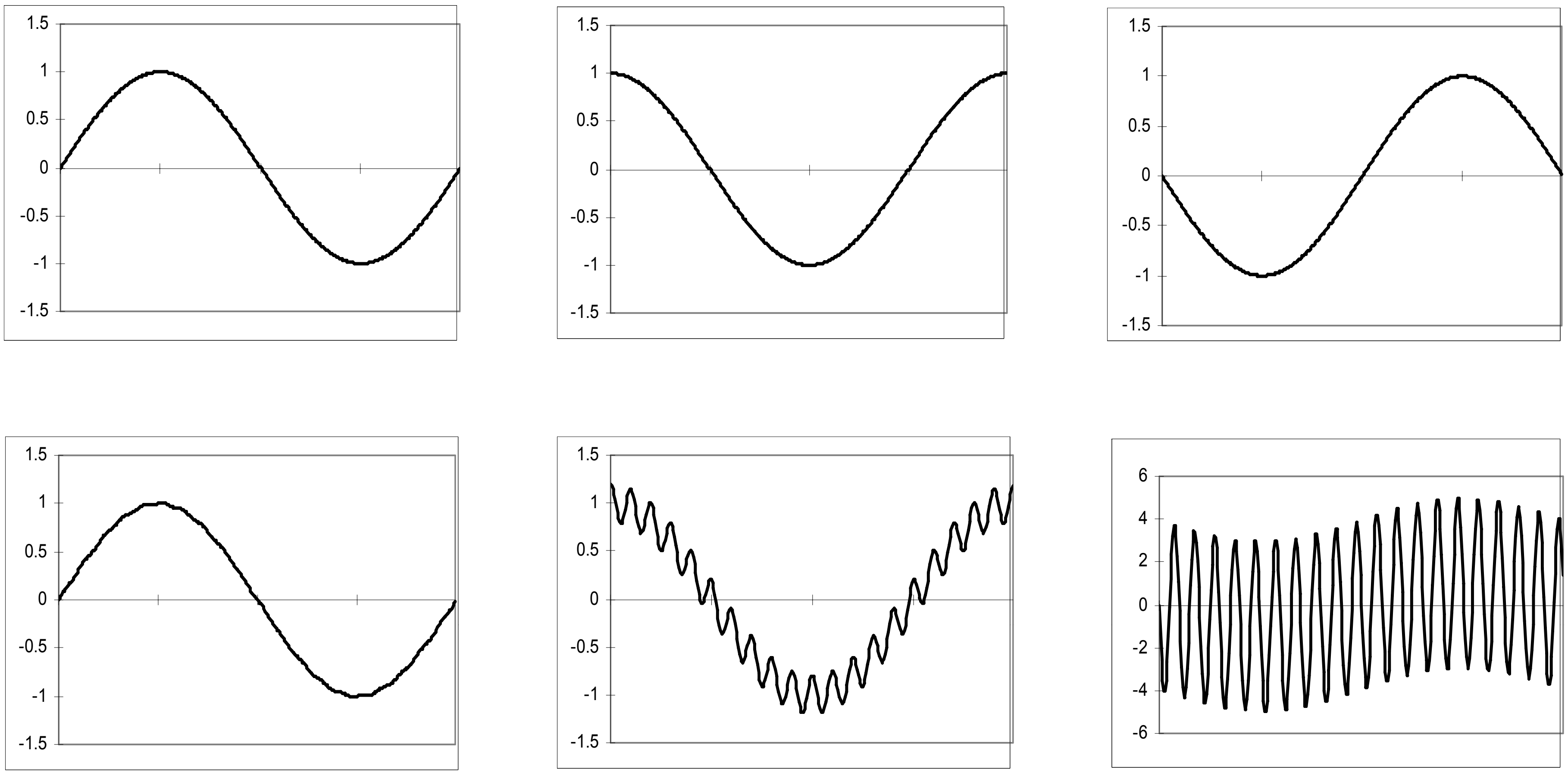
Signal = Σ[aSinx + bCosx] + c

DER(Sina*X) = a*Cosa*X
DER(Cosa*X) = -a*Sina*X

e.g.
DER(0.1*sin(30*X)) = 0.1*30*Sin(30*X)

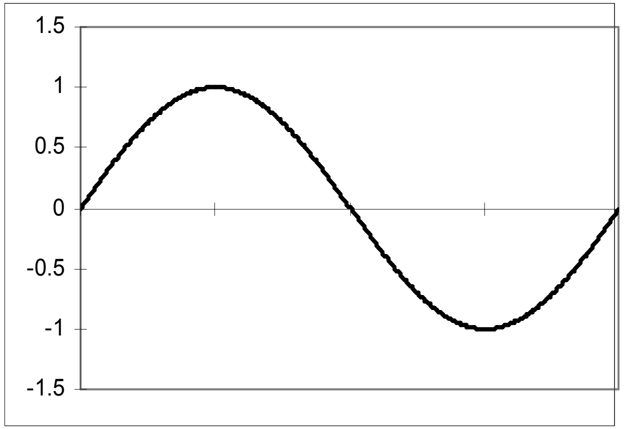
Higher derivatives

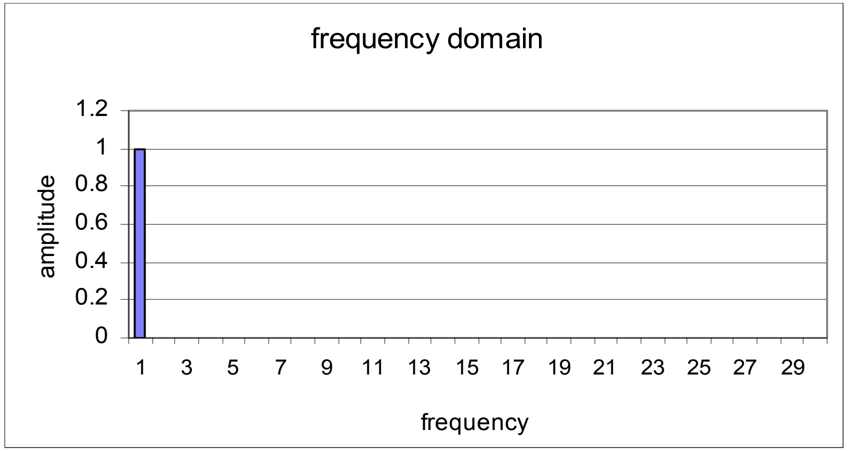
Displacement | Velocity | Acceleration

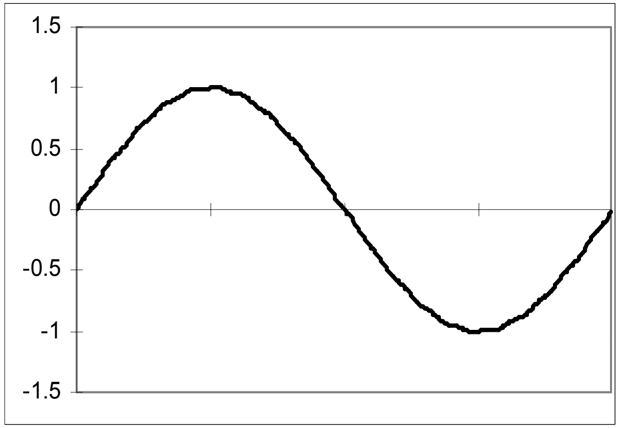


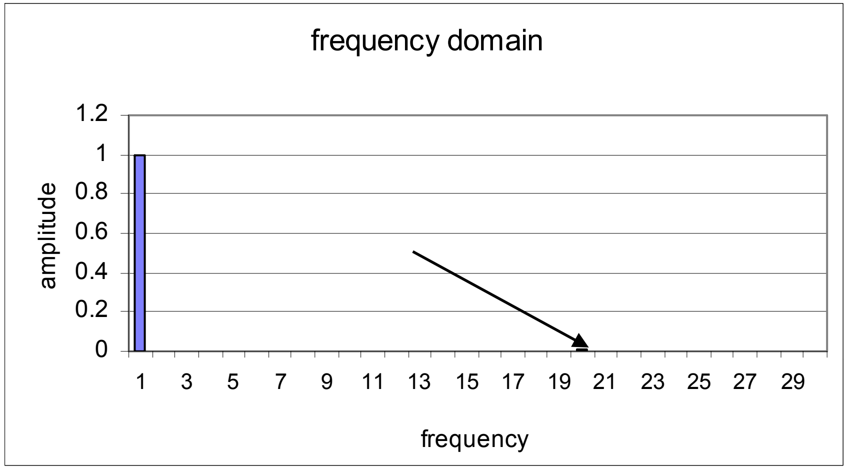
Displacement

Clean signal







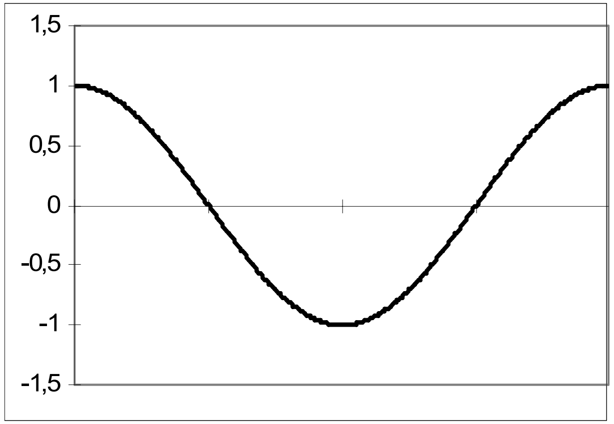


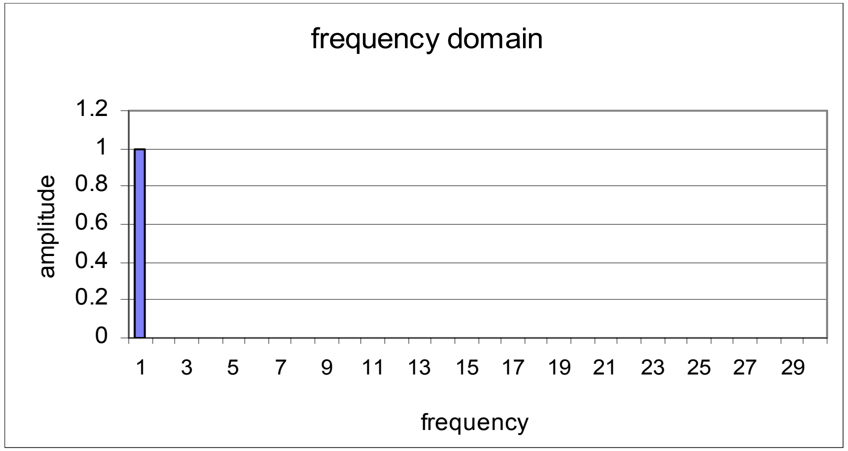
Noisy signal

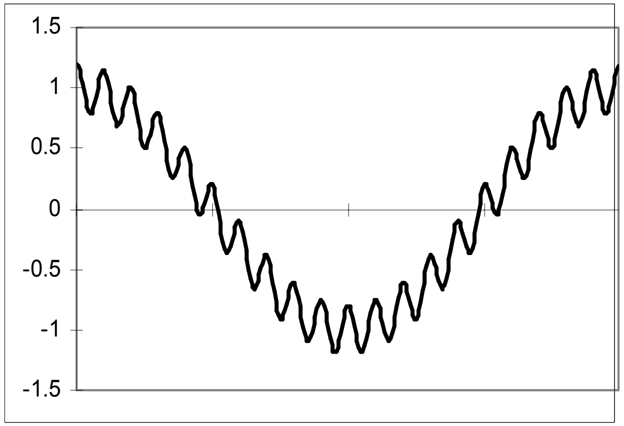
Data reproduced by Hatze (1990)

Velocity

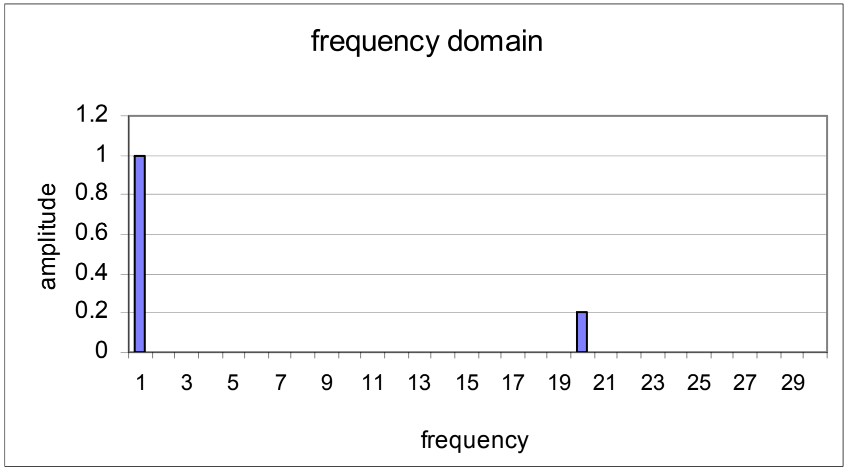
Clean signal







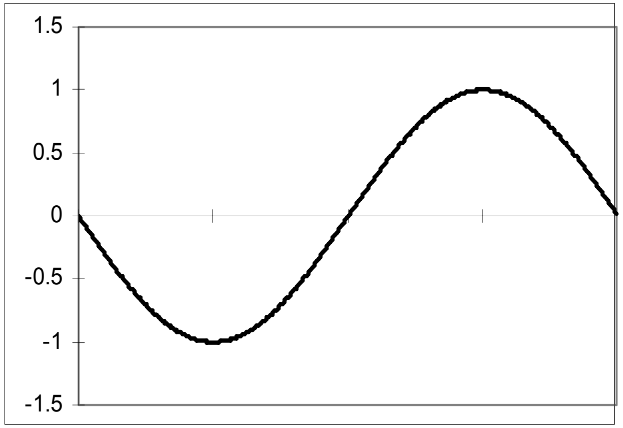
Noisy signal

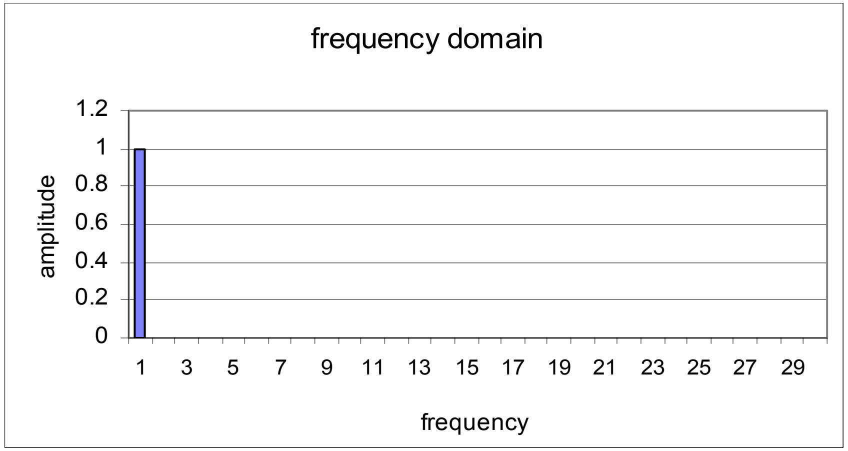


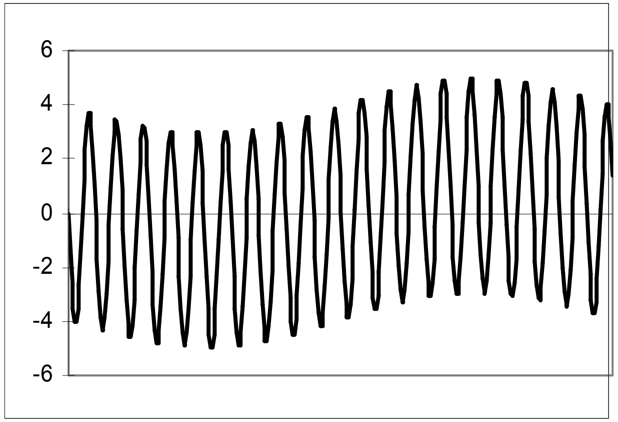
Data reproduced by Hatze (1990)

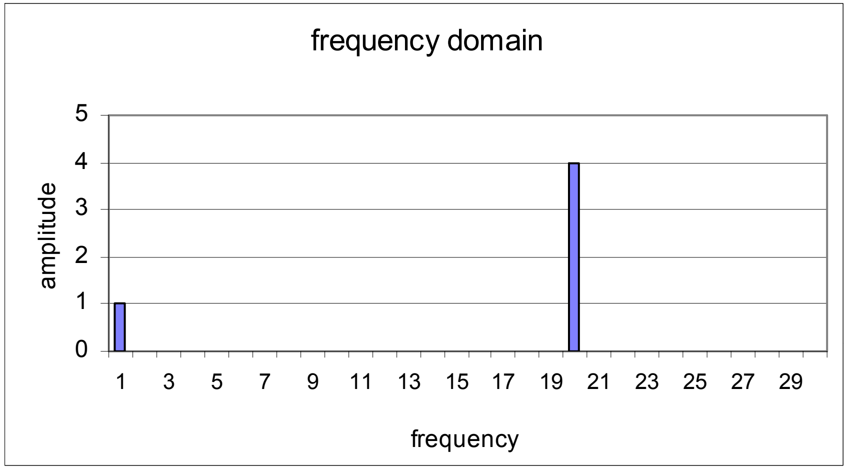
Acceleration

Clean signal





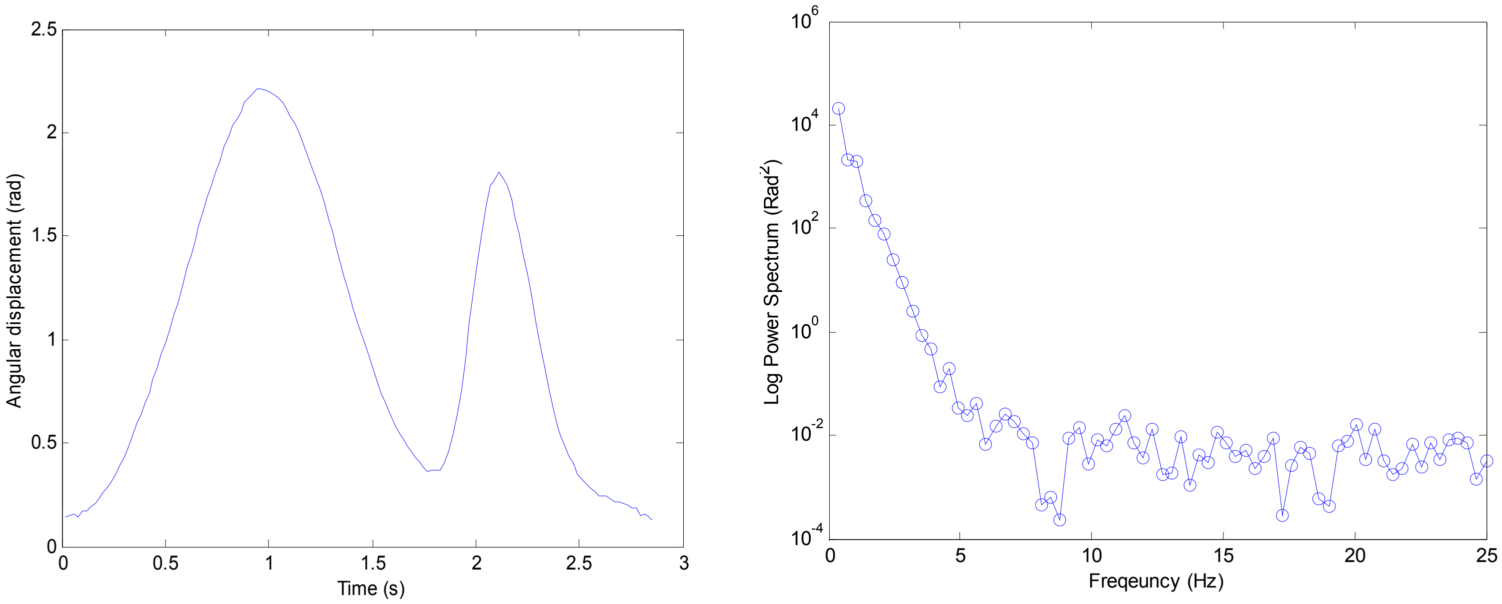




Noisy signal

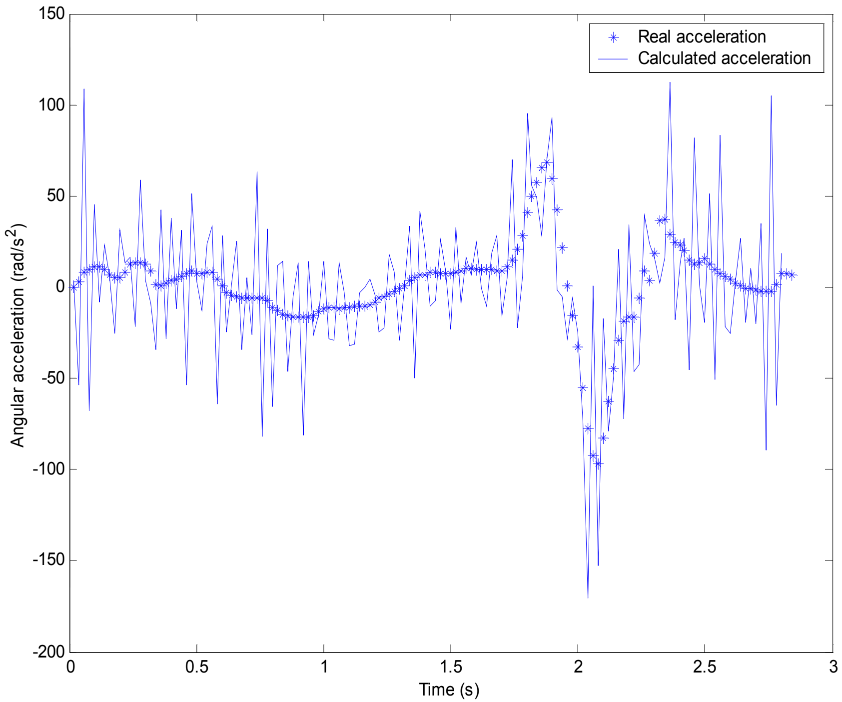
Data reproduced by Hatze (1990)

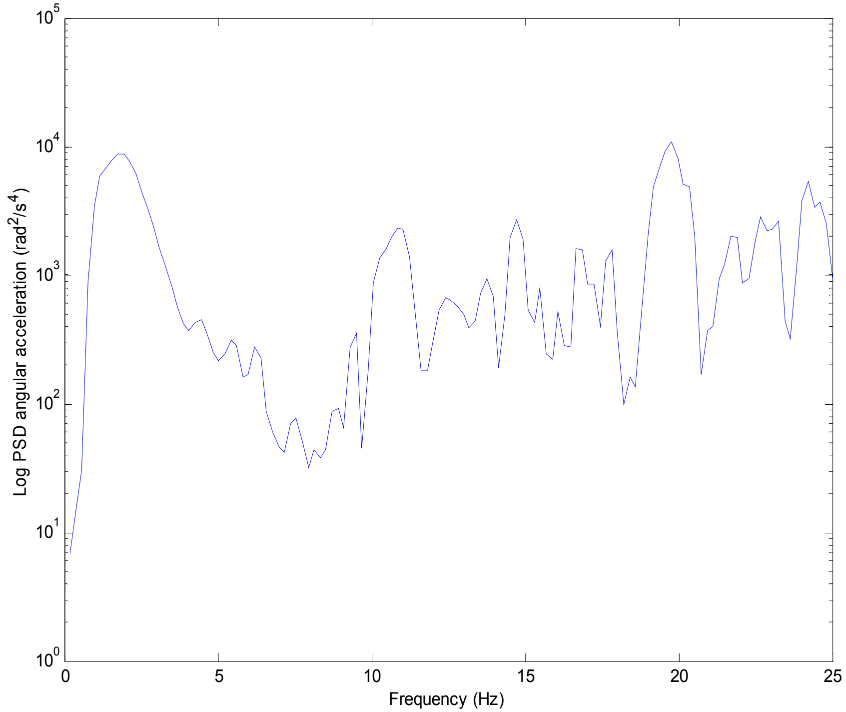
Angular displacement of the elbow



Giakas (2002)

Angular acceleration of the elbow





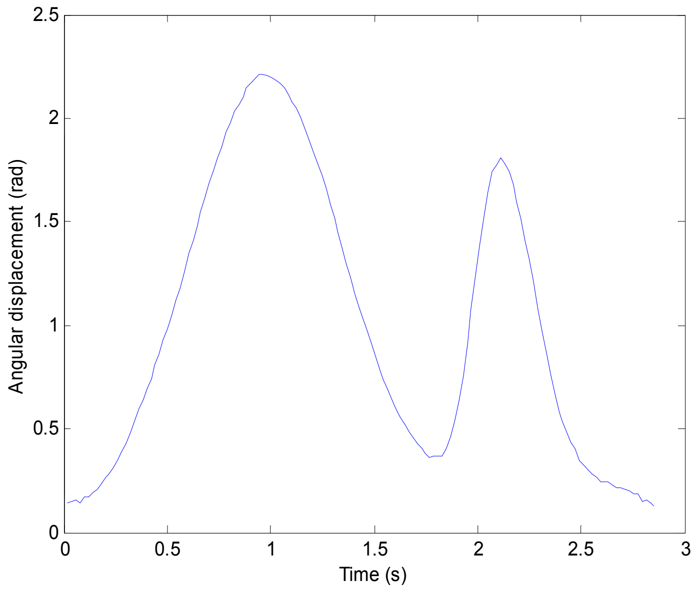
Giakas, Stergioulas and Vourdas, 2000

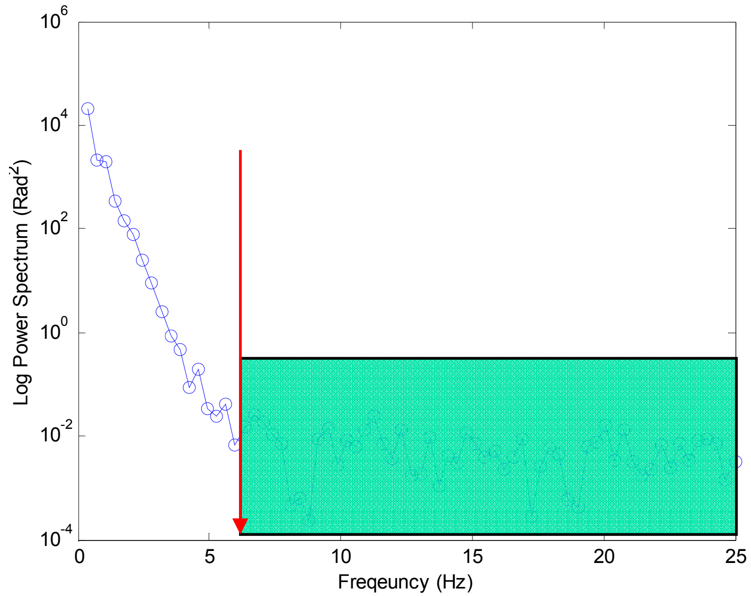
Problems

- Selection of appropriate cut-off frequency
- Differentiation process
- Endpoint distortion

- Signals are non-stationary

Angular displacement of the elbow





Georgakis, Stergioulas and Giakas, 2003

Selection of cut-off

- Winter (1974)
- Hatze (1981)
- Woltring (1986)
- Dohrmann et al (1988)
- Damico and Ferrigno (1990)
- Simons and Yang (1991)
- Giakas and Baltzopoulos (1997a)
- Yu (1999)
- Challis (1999)
- Georgakis, Stergioulas and Giakas (2003)

Differentiation process

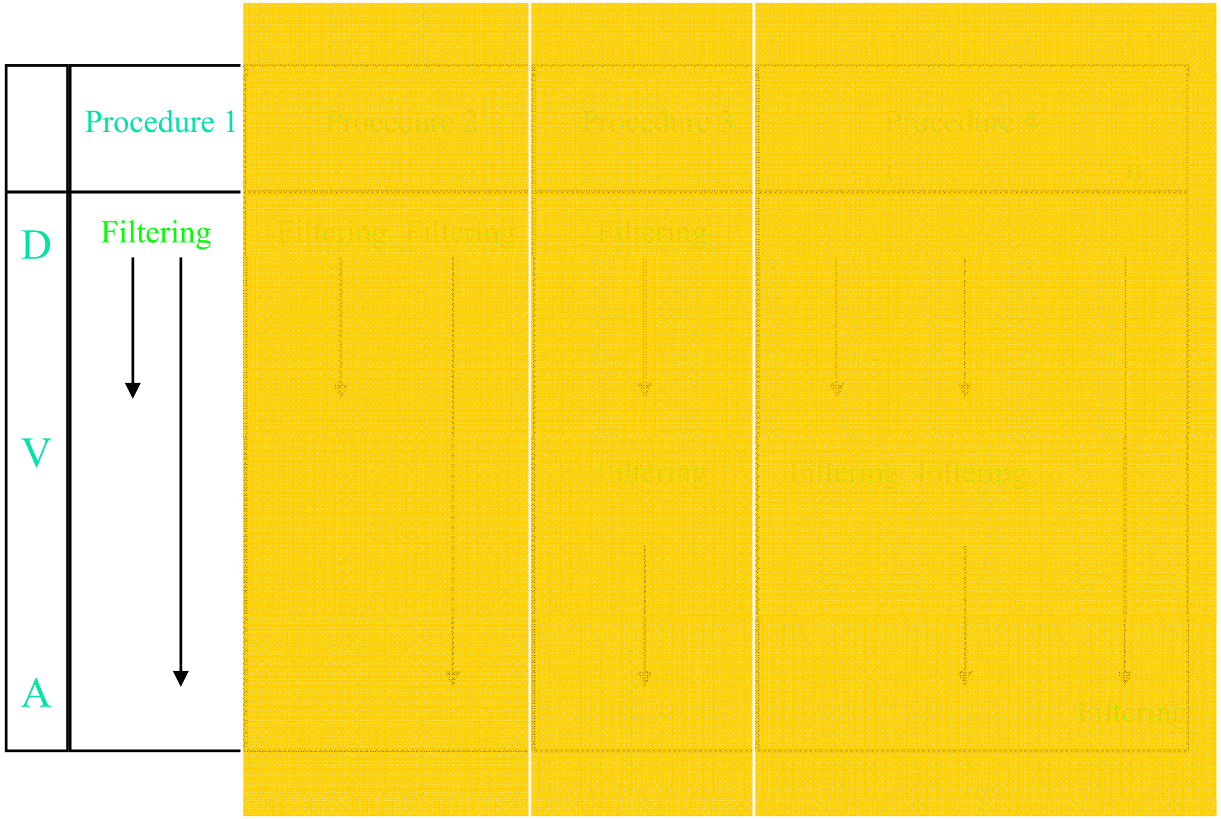
- The calculation of velocity and acceleration requires a different cut-off frequency applied to the displacement data (Hatze, 1981; Giakas and Baltzopoulos, 1997b)

Differentiation process

D: Displacement

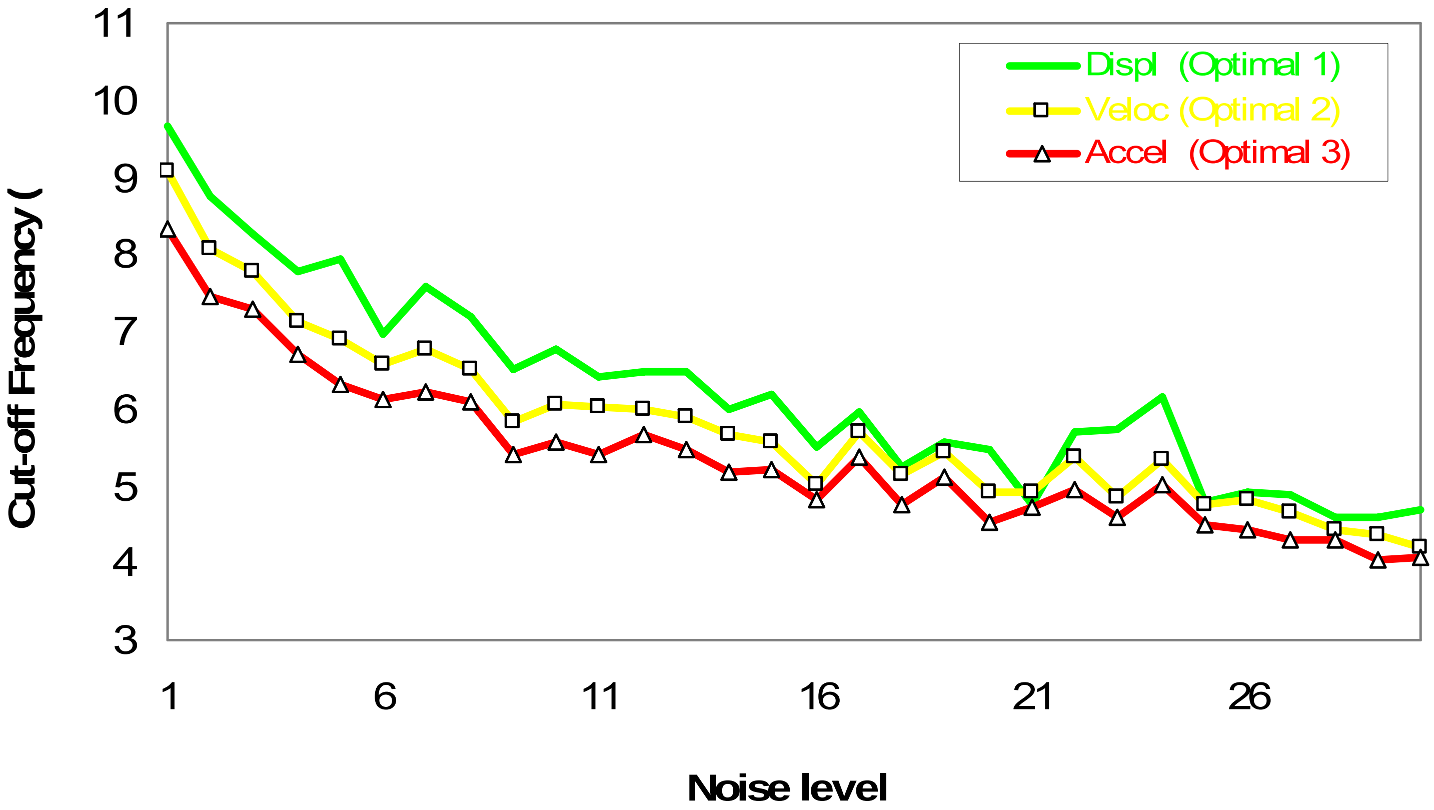
V: Velocity

A: Acceleration



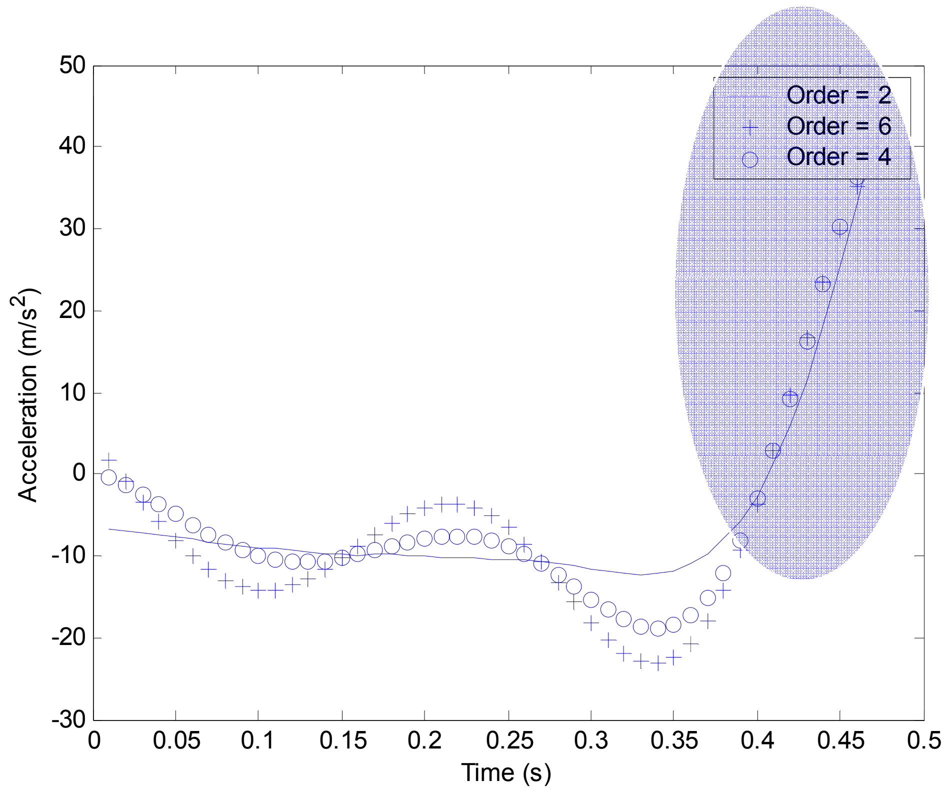
Giakas and Baltzopoulos (1997b)

Differentiation process



Giakas and Baltzopoulos, 1997b

Endpoint distortion

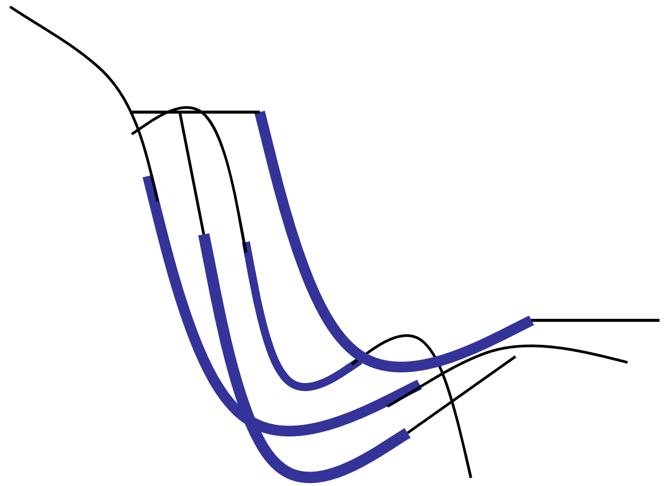


The signal is distorted at the edges when some filters are used

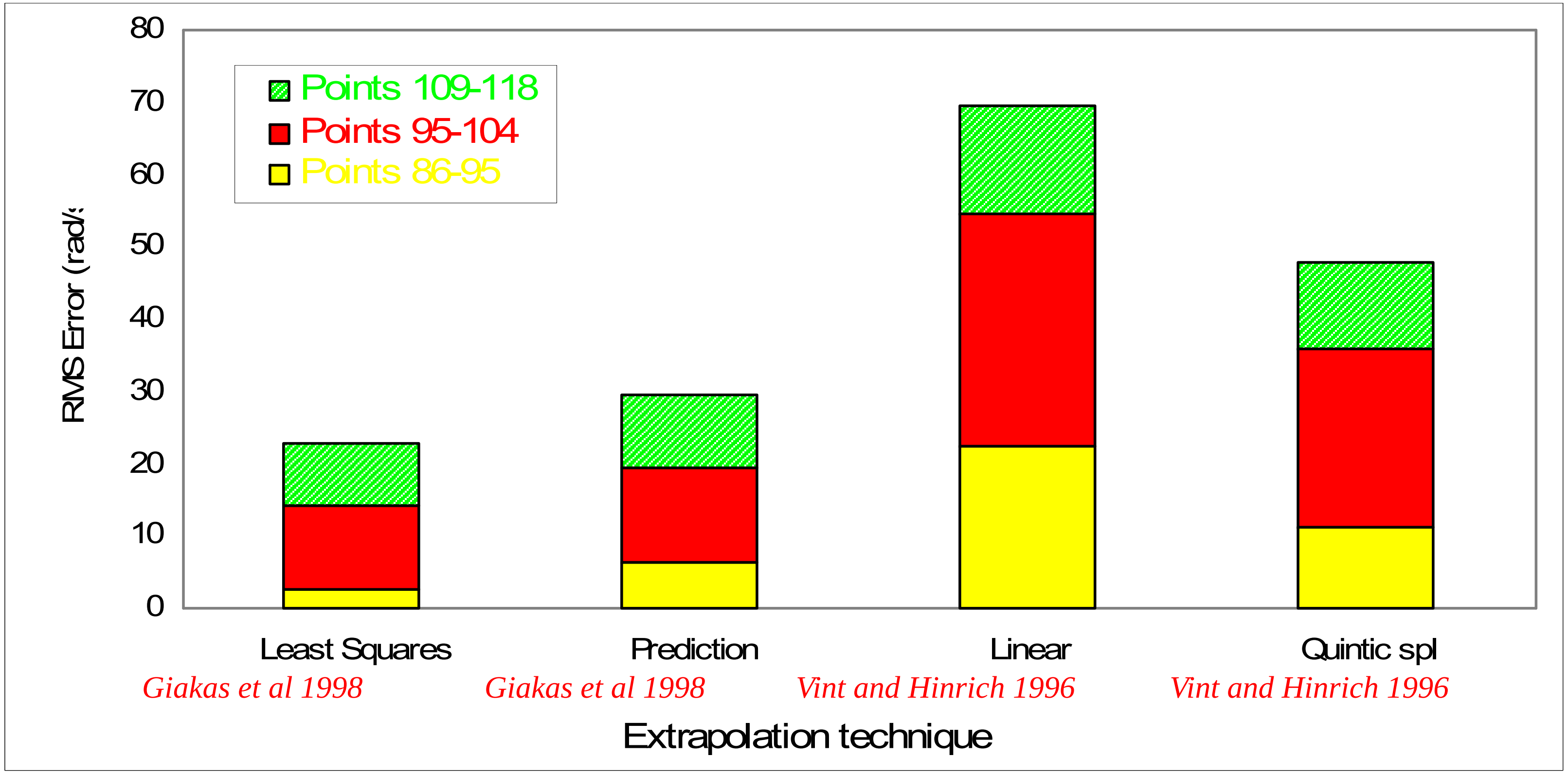
Vaughan 1982

Endpoint distortion

- Smith (1989)
- Vint and Hinrichs (1996)
- Giakas et al (1998)

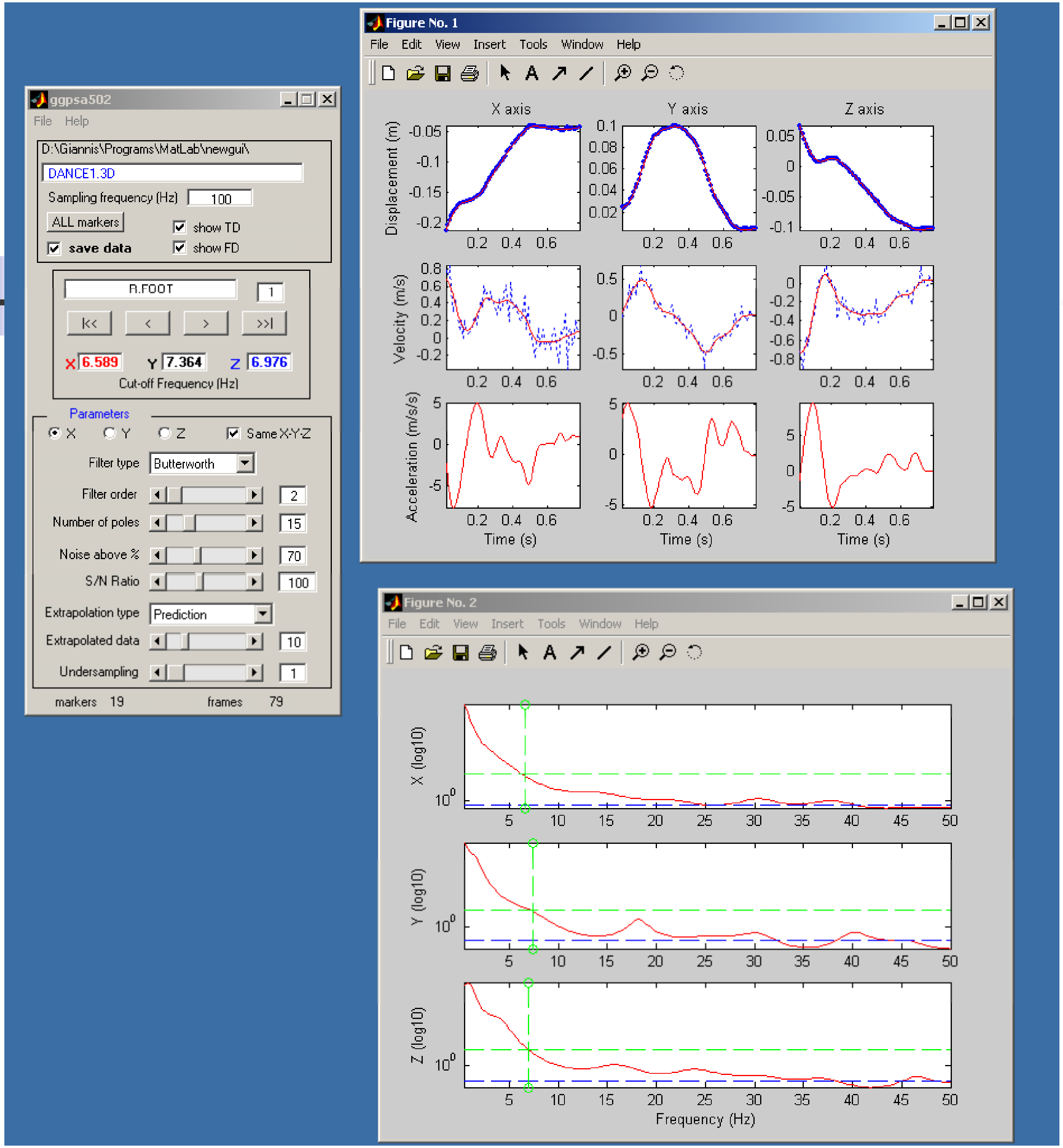


Endpoint distortion



Fundamentals

- Every single point requires a different cut-off frequency
- Every axis (of the same point) requires a different cut-off frequency
- Different data collection settings require adjustment of the filtering parameters


ggpsa502
File Help
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DANCE1.3D
Sampling frequency (Hz) 100
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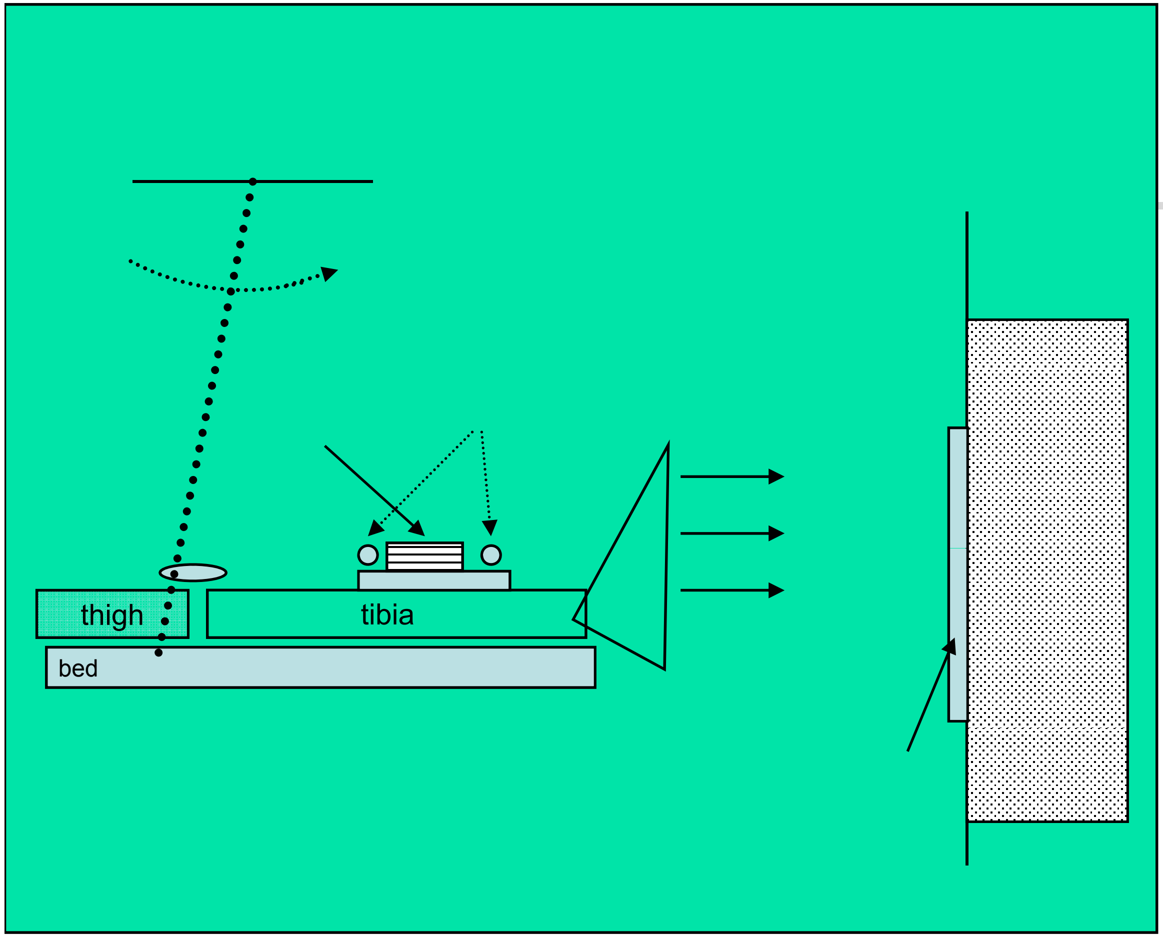
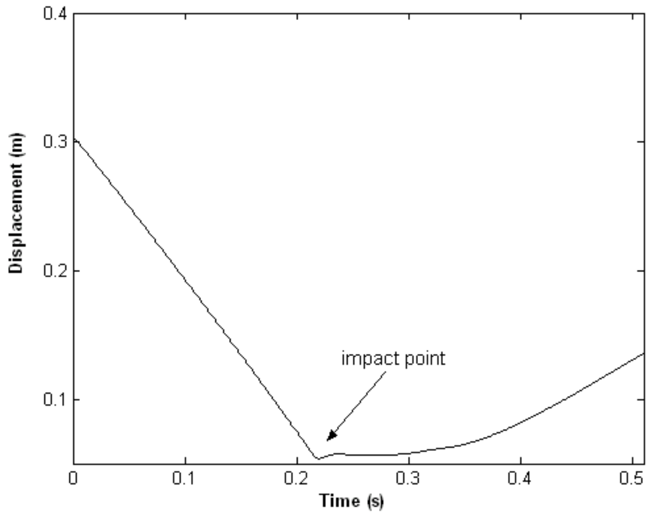
show FD
R.FOOT 1
X 6.589 Y 7.364 Z 6.976
Cut-off Frequency (Hz)
Parameters
X Y Z Same X-Y-Z
Filter type Butterworth
Filter order 2
Number of poles 15
Noise above % 70
S/N Ratio 100
Extrapolation type Prediction
Extrapolated data 10
Undersampling 1
markers 19 frames 79
Figure No. 1
File Edit View Insert Tools Window Help
X axis
Y axis
Z axis
Displacement (m)
Velocity (m/s)
Acceleration (m/s/s)
Time (s)
Figure No. 2
File Edit View Insert Tools Window Help
X (log10)
Y (log10)
Z (log10)
Frequency (Hz)



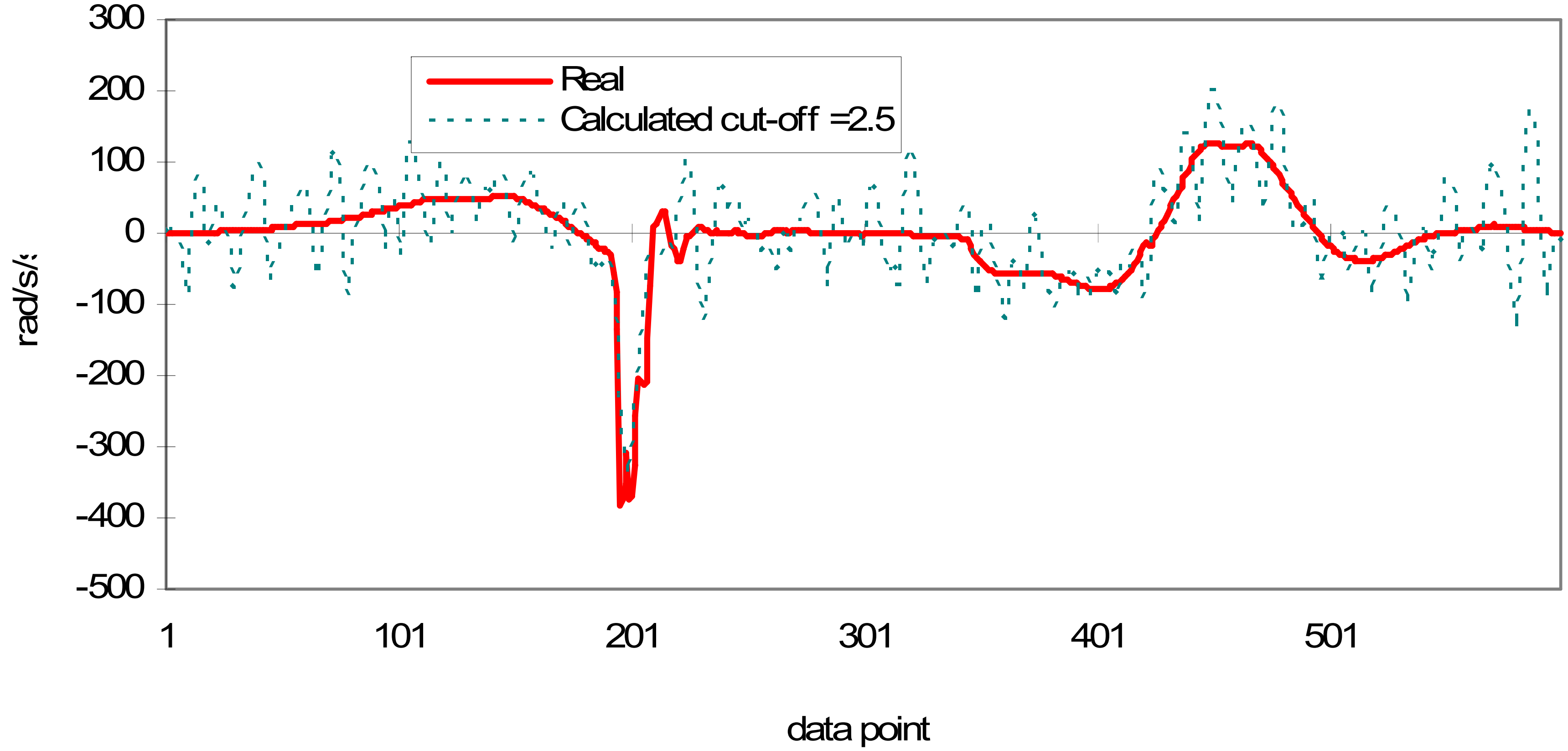


Georgakis, Stergioulas and Giakas 2003

Signals are non stationary

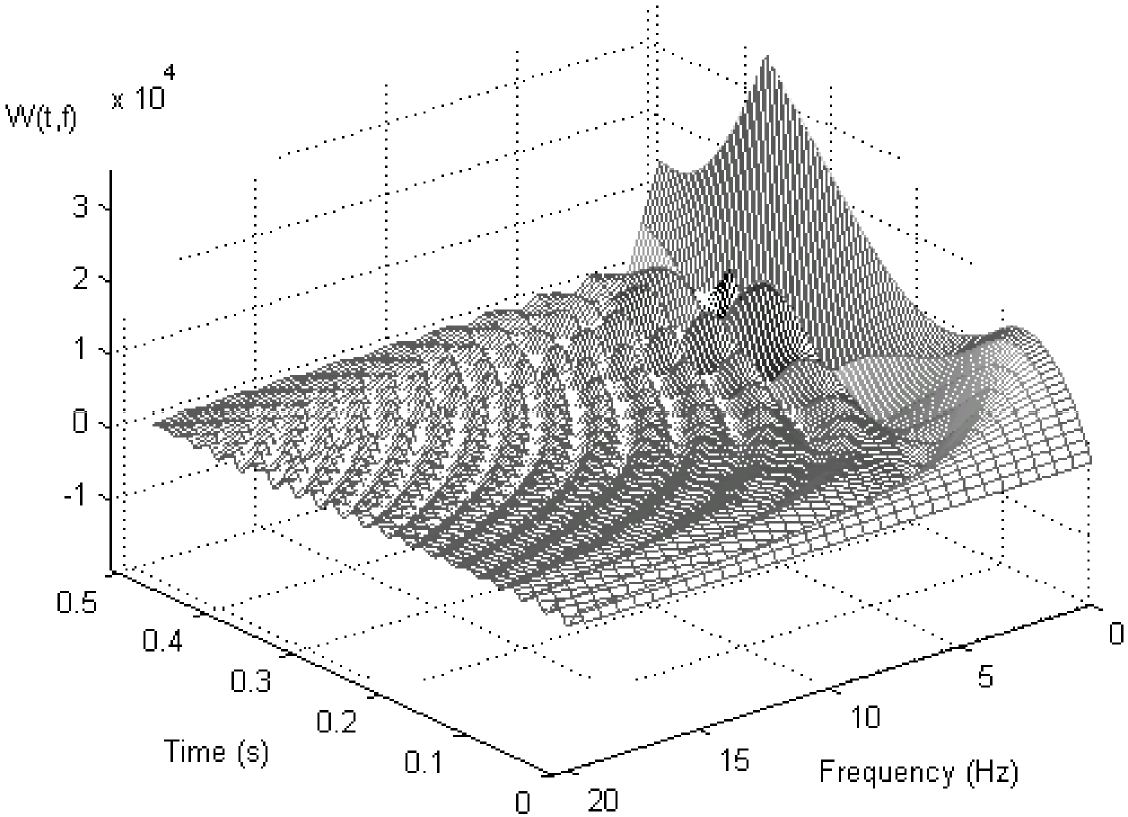
Giakas, Vourdas and Stergioulas 2000

Signals are non stationary



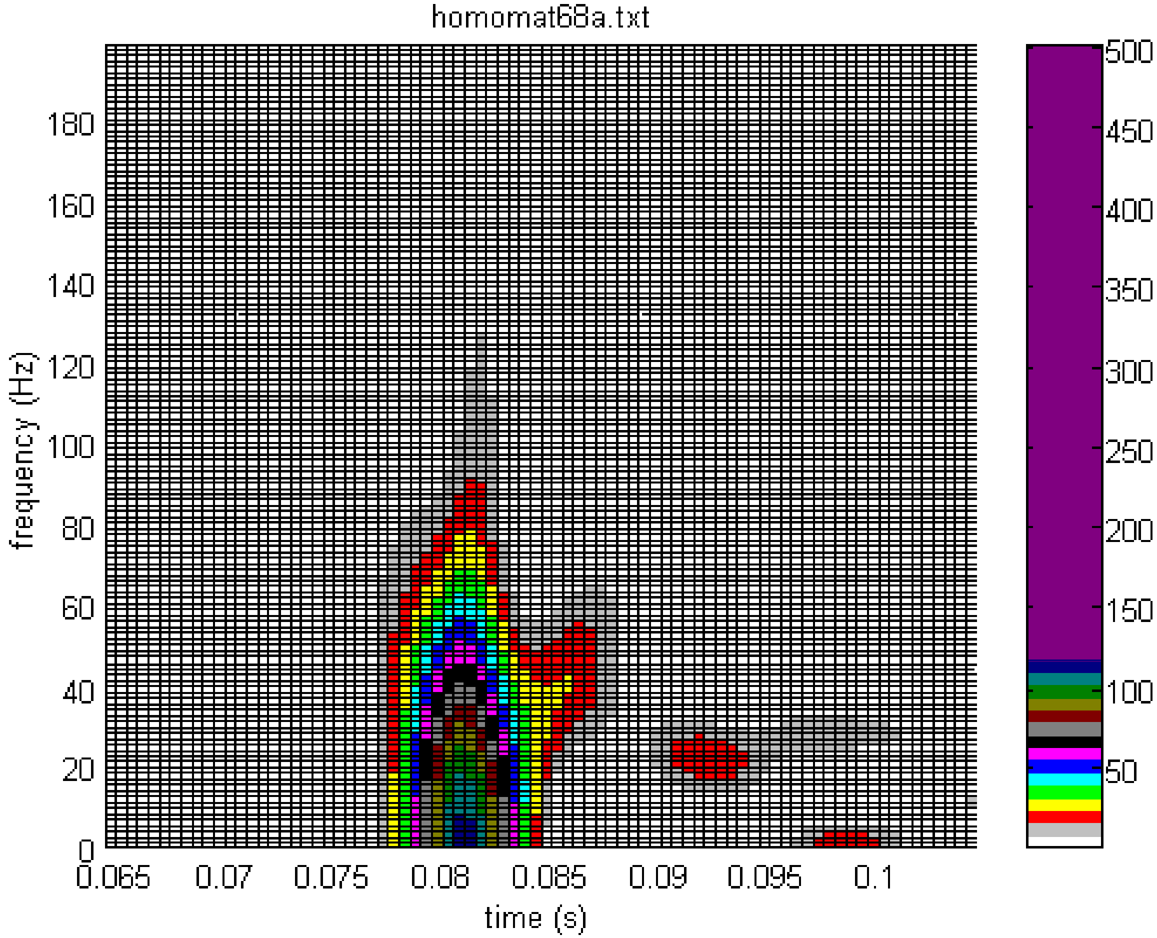
Giakas, Stergioulas and Vourdas 2000

Joint time frequency analysis



Georgakis, Stergioulas and Giakas 2003

Signals are non stationary



Georgakis, Stergioulas and Giakas 2003

http://isb.ri.ccf.org/software/ISBS99/GGPSA/

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