# Alternative methods of EEG signal analysis

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# Presented methods

- Traditional methods
  - Fourier transform
- Parametrical methods
  - Autoregressive estimator
- Nonlinear methods - Chaos theory
  - Delay-time embedding, Correlation dimension, State Space dimension

# EEG activity

- electric potential of brain's neural activity
- registered on the skelet
- four basic frequencies

| Name | Freq. [Hz] |
|---|---|
| Deltha | 0,5-4 |
| Theta | 4-8 |
| Alpha | 8-15 |
| Beta | 15-35 |

# Traditional methods

**Estimate of a periodogram using the Fourier transform**

## Potencial problems

- Signal's stationarity
- frequency resolution
- leakage of frequency spectra
- quality of the spectral estimate
- phase of the signal is lost

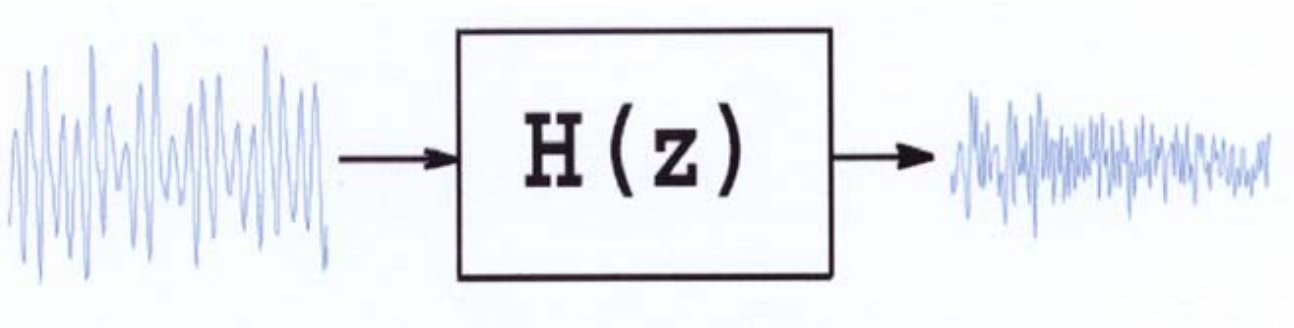
# Parametrical model

**Approximation of an EEG signal by adequate parametrical model**

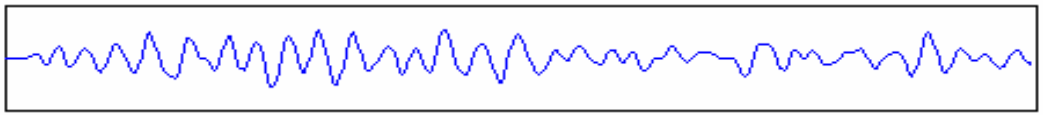
## Autoregressive (AR) model:

Approximation of an EEG signal by linear time invariant filter with transfer function H(z)=1/A(z)

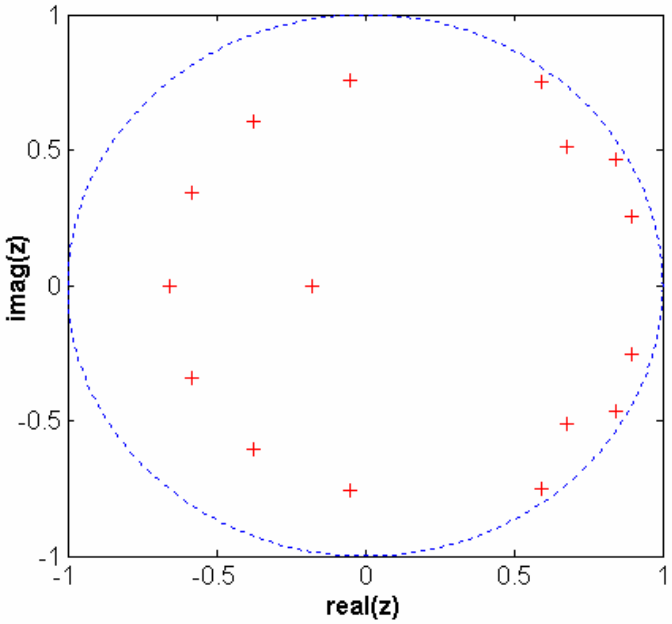
## Whitening of signal by AR filter:



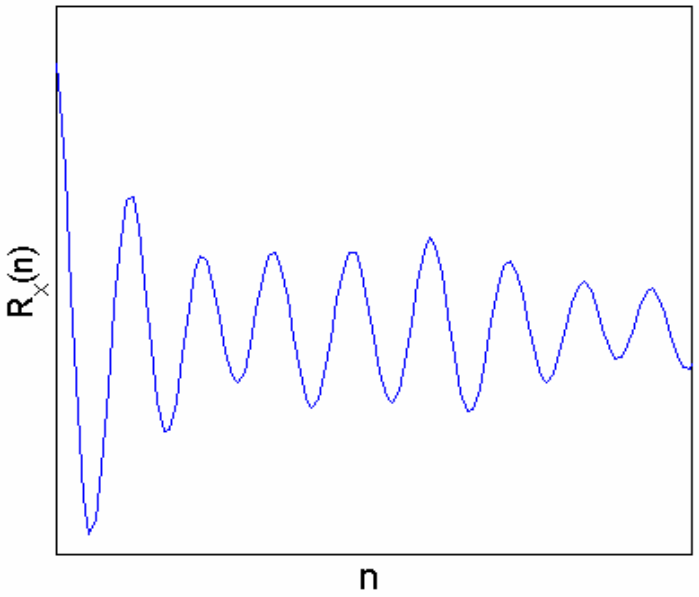
Analyzed signal



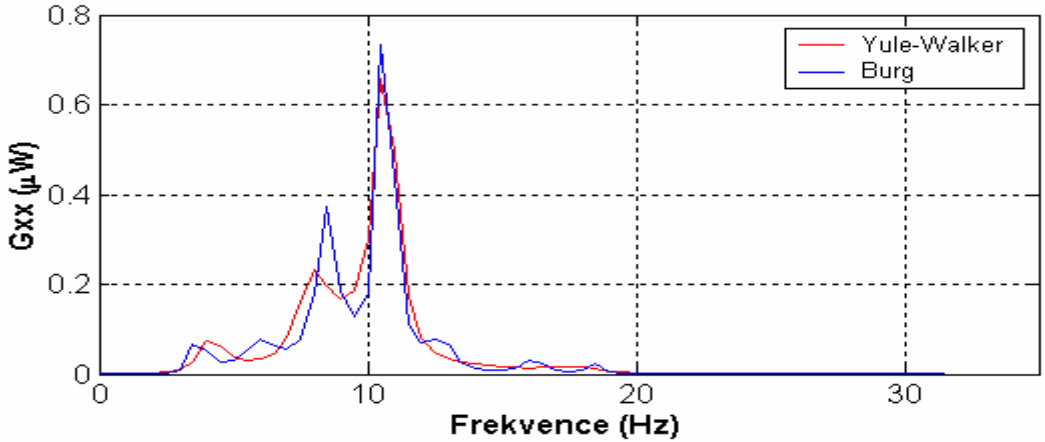
Pole placement




Autocovariance function




Spectral estimate



# Comparison of traditional and parametrical methods

**Traditional methods:**

+ low noise sensitivity
- frequency resolution

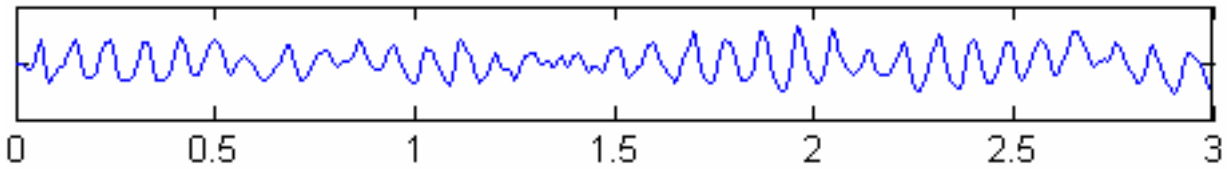
**Parametrical methods:**

+ frequency resolution
+ parametrical description of analyzed signal
- estimate of AR model order
- high noise sensitivity

# Chaos theory

- Analysis of dynamic deterministic systems
- high sensitivity on initial conditions
- known dynamics and phase of the system
- delay-time embedding
  - state-space dimension estimate
  - estimate of delay time
- estimate of fractal dimension

# Delay-time embedding



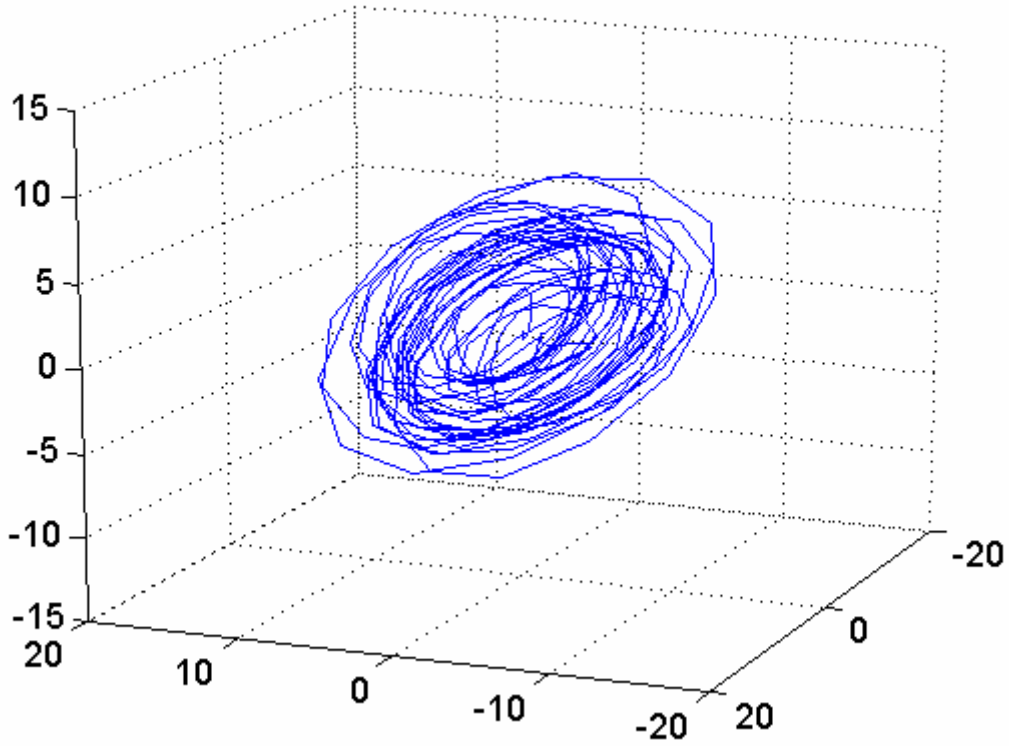

$$S_i = [x(i), x(i+L), \ldots x(i+(m-1)L)]$$

L… dime delay

$S_i$… state-space vector

m… state dimension

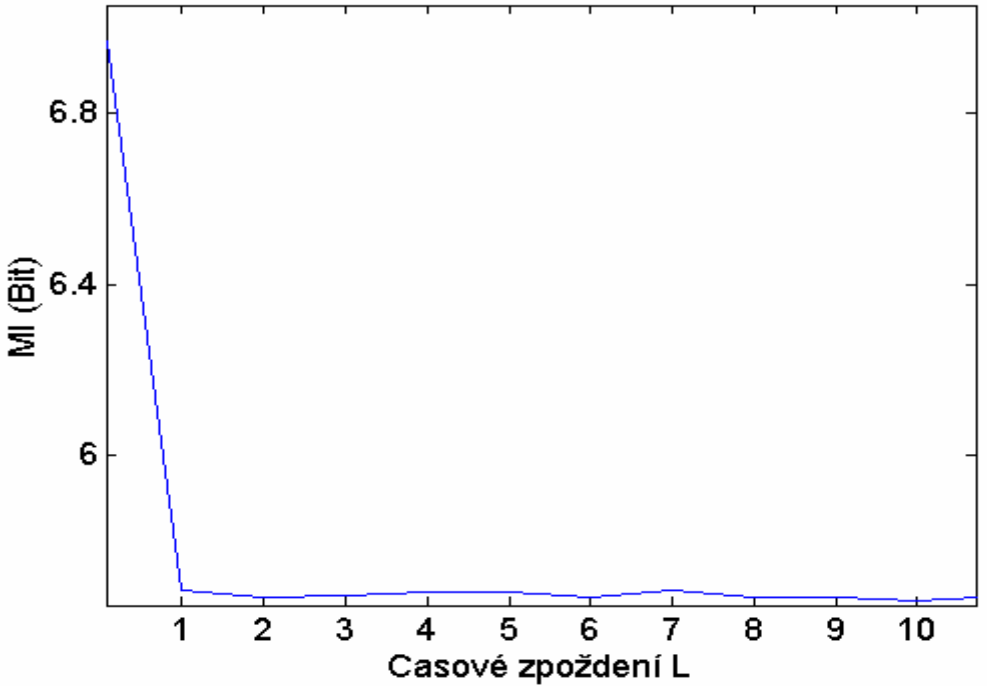
x… analyzed signal



# Selection of Delay Time L

Time delay should be set so, x(i),x(i+L),… are independent

- Autocorrelation method
- method of Mutual Information (MI)



# Microsleep classification

## Traditional methods

- Alpha and deltha activity of spectral estimate

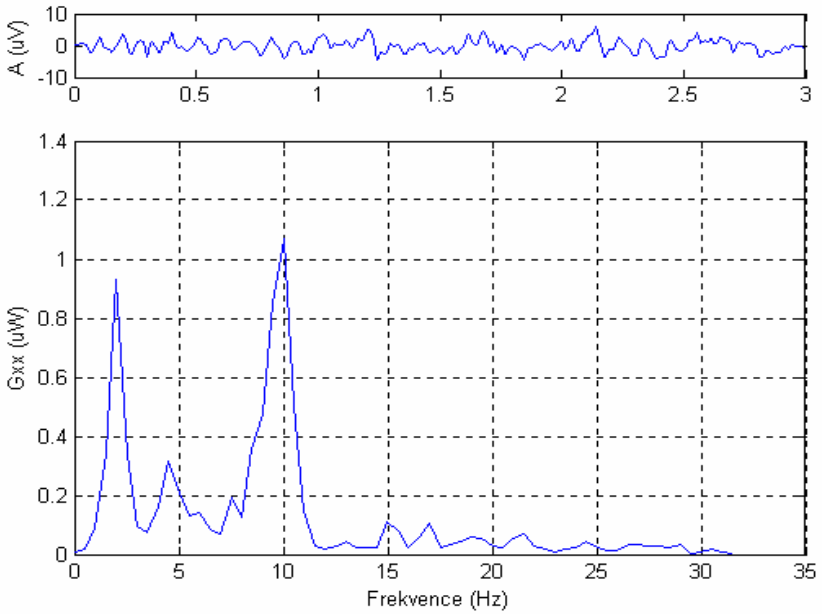
## Parametrical methods

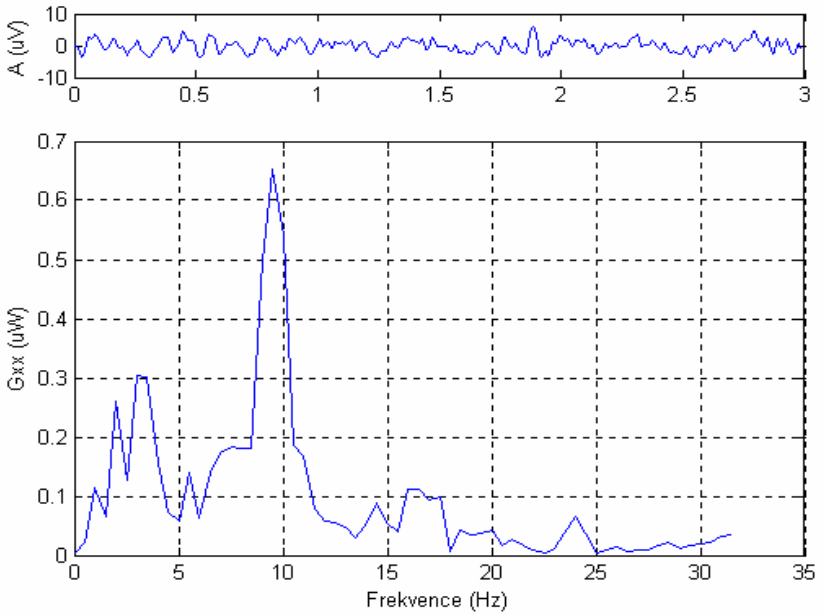
- poměr alfa a delta aktivity spektrálního odhadu
- estimate of AR model order
- placement of poles in a complex plane

## Chaos theory

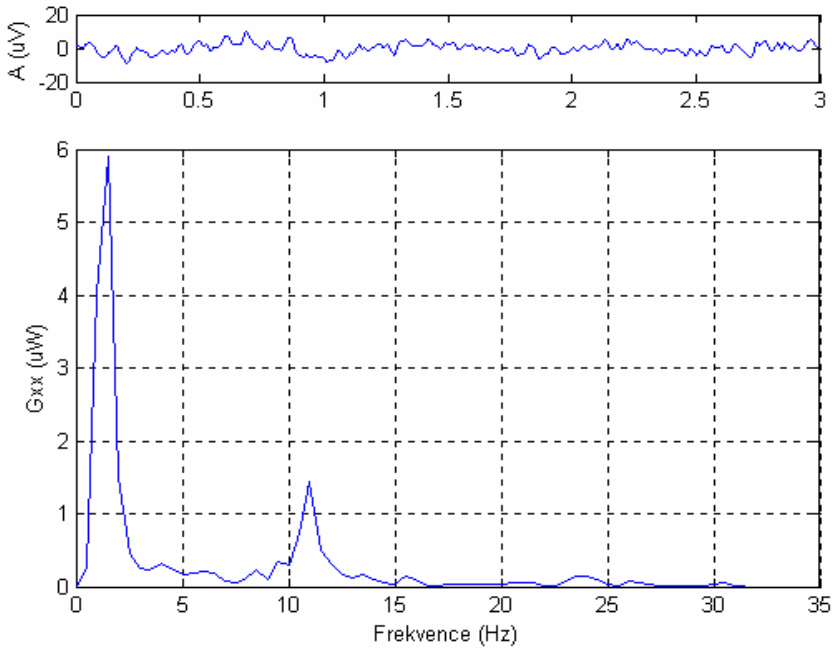
- State-space trajectory reconstruction
- correlation dimension estimate

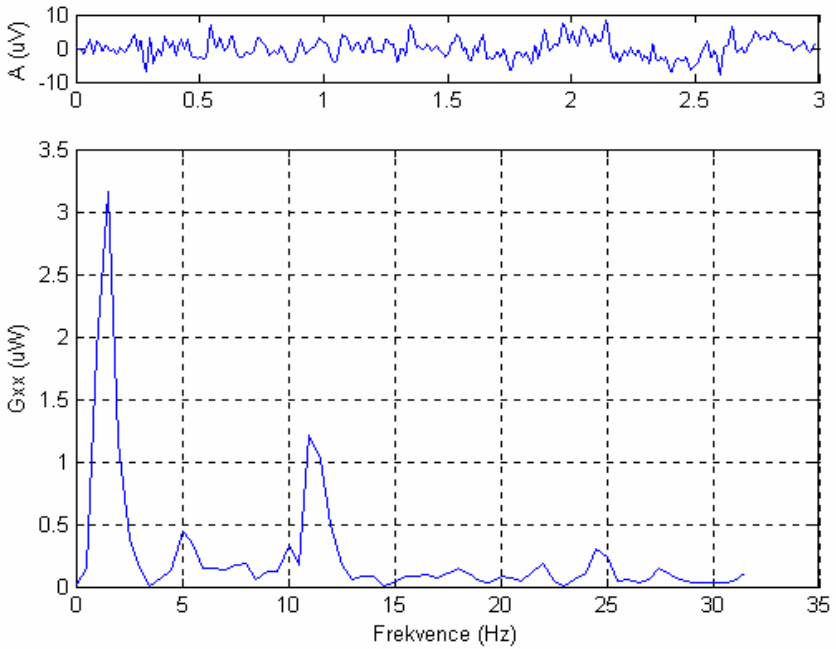
# Relaxation

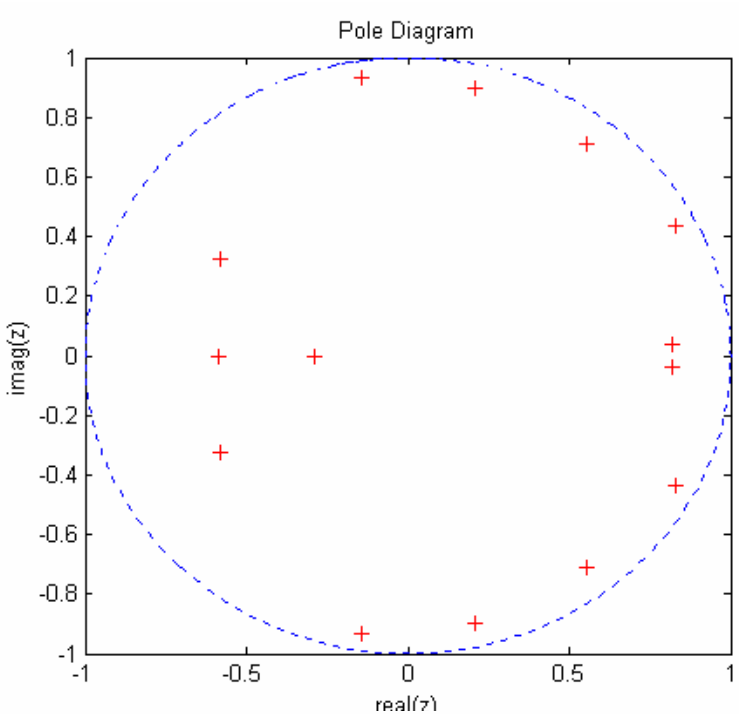


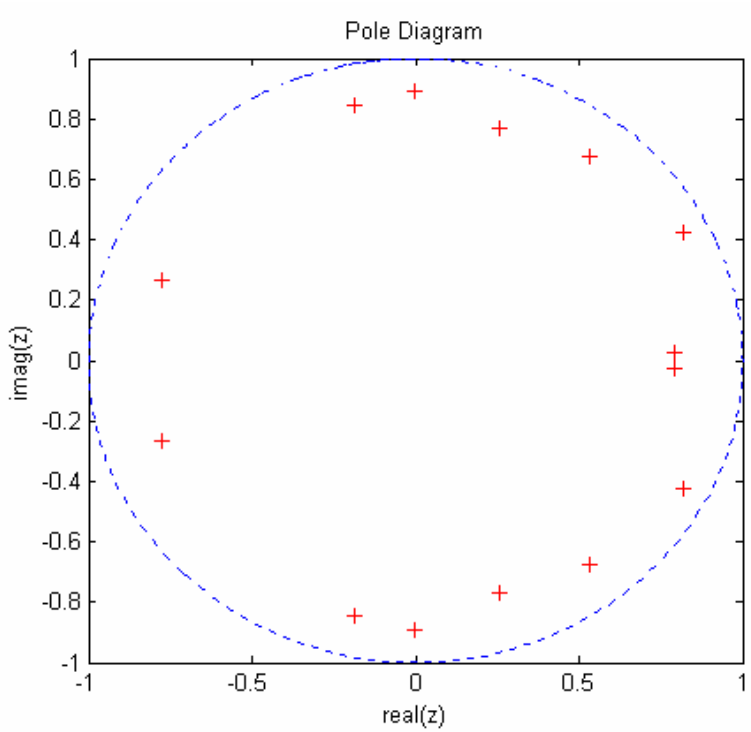




# Drowsiness




Pole Diagram
imag(z)
real(z)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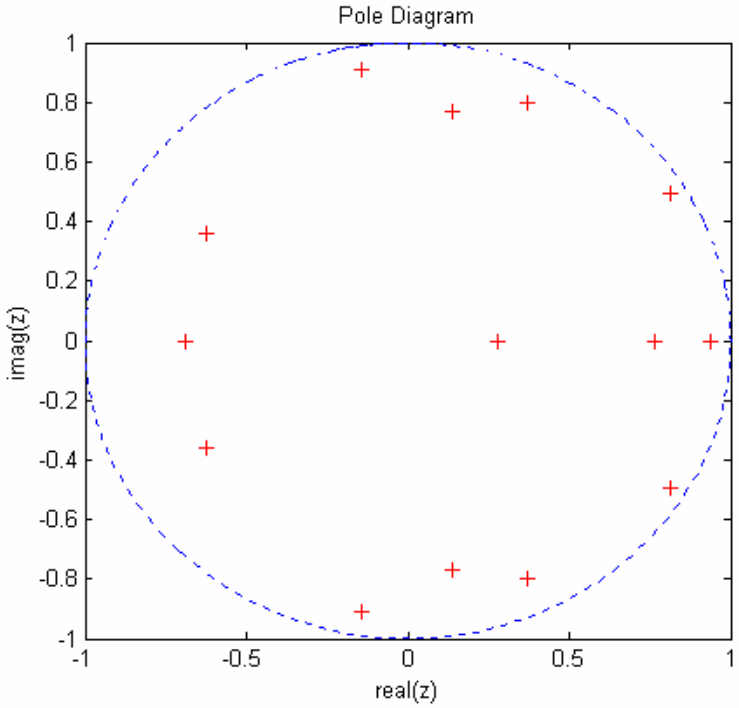
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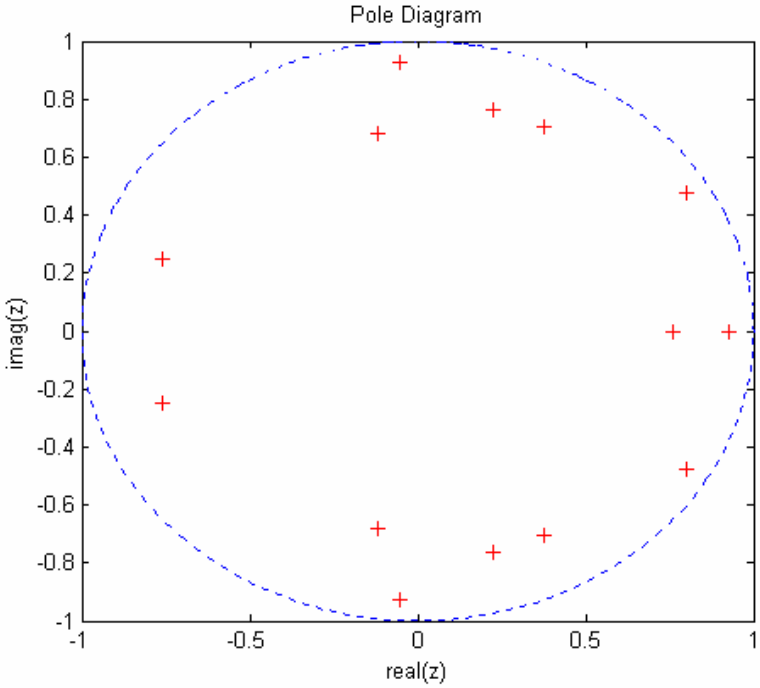
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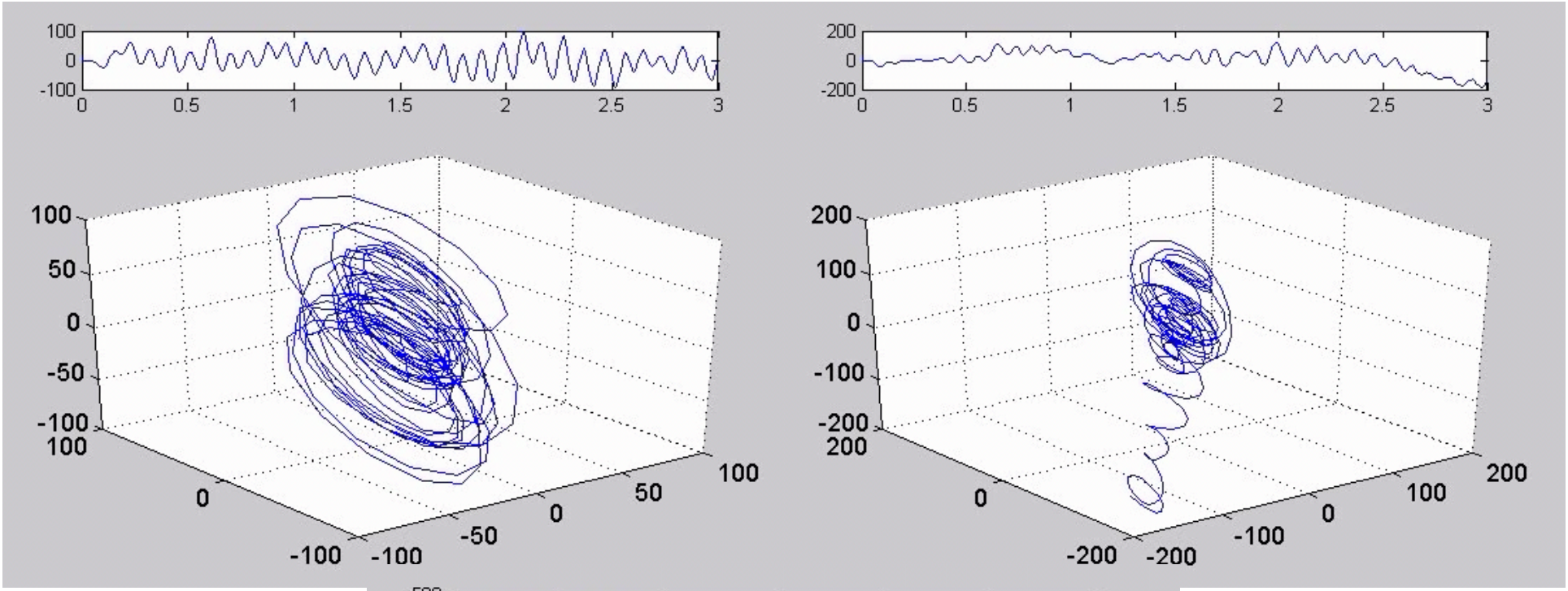
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