# INTERDISCIPLINARY IT RESEARCH: DIGITAL SIGNAL PROCESSING

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# Content

1. T-model of Computer Science specialist preparation
2. Interdisciplinary nature of Digital Signal Processing
3. DSP and Computer Science foundations
4. Simple and complicated things in DSP
5. DSP practical applications
6. Mathematical problems in DSP
7. DSP software
8. Conclusions

# T-model of Computer Science specialist preparation

1. Computer science specialist should be “T-similar”
2. Specialist should have broad knowledge in many areas.
3. There should be area where he/she is deep specialist
4. Universities teach to be deep better than to be broad
5. It is necessary to pay special attention to teach to be broad
6. The best way to do this is interdisciplinary approach
7. There are not so many interdisciplinary topics
8. First is differential equations in physics and mathematics
9. Second is digital signal processing

# Interdisciplinary nature of Digital Signal Processing

1. There are several areas of information technologies (IT) practical implementations, where in the most explicit way are observable effects, which can be called as interdisciplinary. In means, that almost identical data processing procedures can be used in a very different and looking not related with each other practical applications.
2. DSP has almost unique combination of properties, which makes it very attractive from methodological, theoretical and practical points of view.
3. At Ventspils University College we are working to make DSP as one of core elements for IT students preparation and recommend to do the same for other universities.

# DSP and Computer Science foundations

1. DSP has deep relations with computer science foundations.
2. At the stage of first year students teaching to abstract Turing, Post, von Neumann, Markov machines we stress, that input text transformation into output text is possible for texts of different natures - not only for alphabet symbols strings (words) but for real time data from different sensors (signals) also.
3. The interpretation of signals as input “words” for future processing allows to describe many possibilities to use computers as measurement and control tools for industrial processes, manufacturing, telecommunications and describe digital signal processing as a base for industrial electronics.

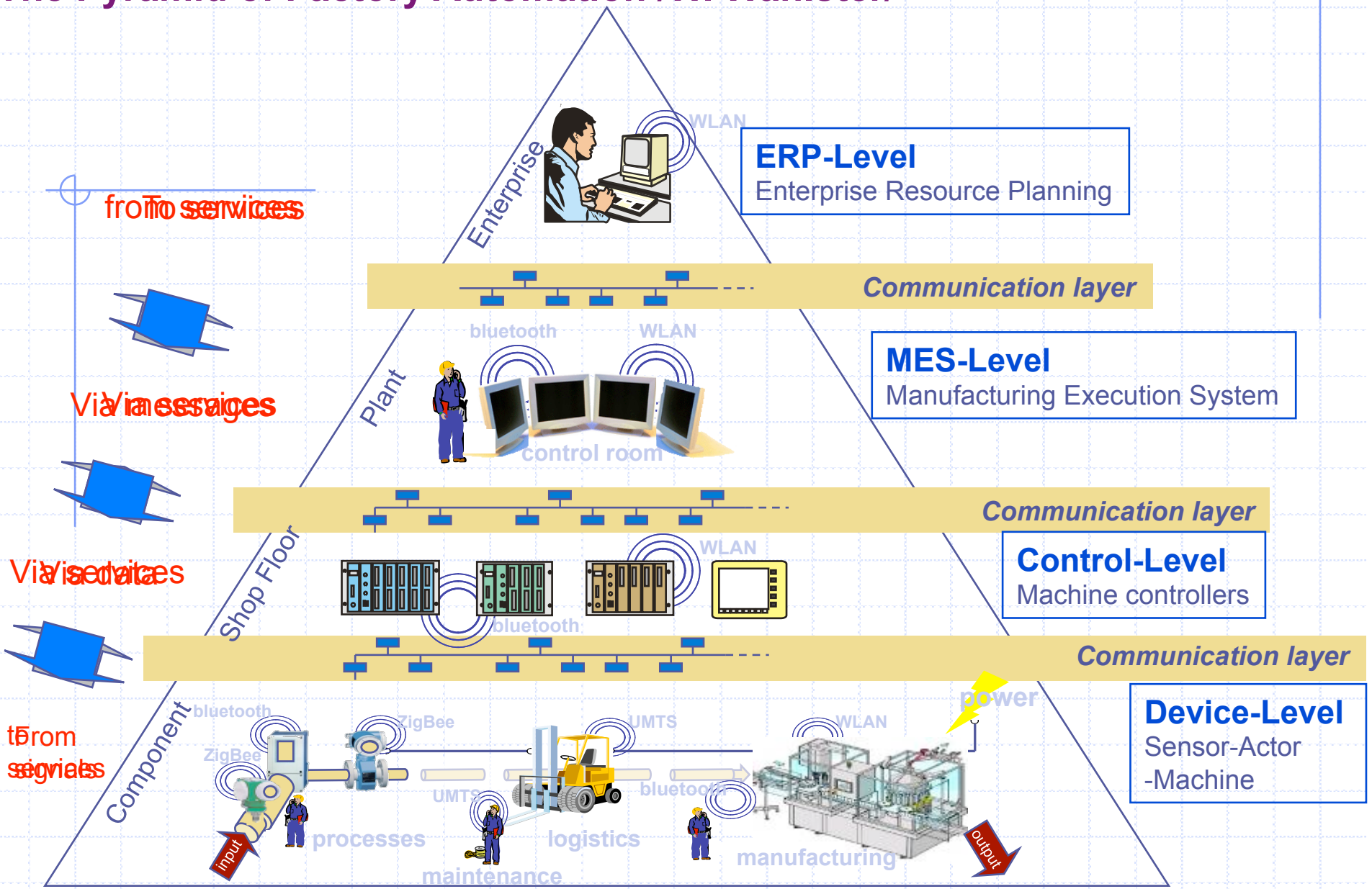
# Simple and complicated things in DSP

1. DSP is simple for beginners.
2. Digitalized and recorded signal from data storing point of view is file and elementary signal processing procedures (calculation of moving averages and deviations) are so simple and evident, that study of them is very pleasant for even weak students.
3. The possibility to reach interesting and significant results (e.g. low frequency speech receiving by demodulation from high frequency radio signal) by simple methods is very attractive for students.
4. There are so many complicated things in computer science that something efficient, but relatively simple, is accepted by students with enthusiasm

# DSP practical applications

1. DSP has many practical applications.
2. Many practical tasks are related with DSP and together with Department of Mathematical Modeling of Engineering Research Center of Ventspils University College we created such tasks collection.
3. We have samples of tasks which were solved by DSP from industrial mathematics (identification of leaks in pipe lines), financial mathematics (currency exchange rate analysis), exact measurements (very large base radioastronomy), business administration (sells forecasting)

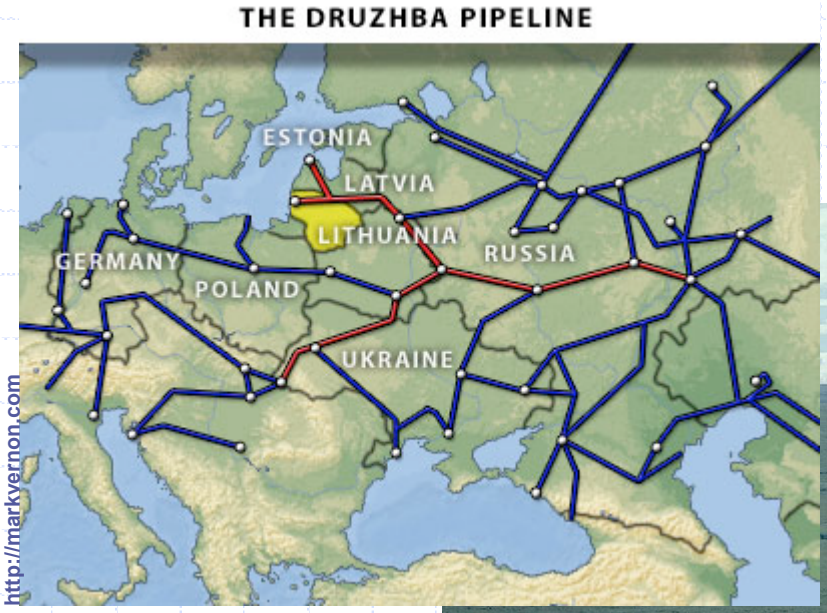
# The Pyramid of Factory Automation /W. Wahlster/



# Samples of DSP practical applications

1. Pressure oscillation analysis in pipelines
2. Exact measurements in radioastronomy
3. Forecasting in marketing
4. Financial time series

# Pressure oscillations in pipelines

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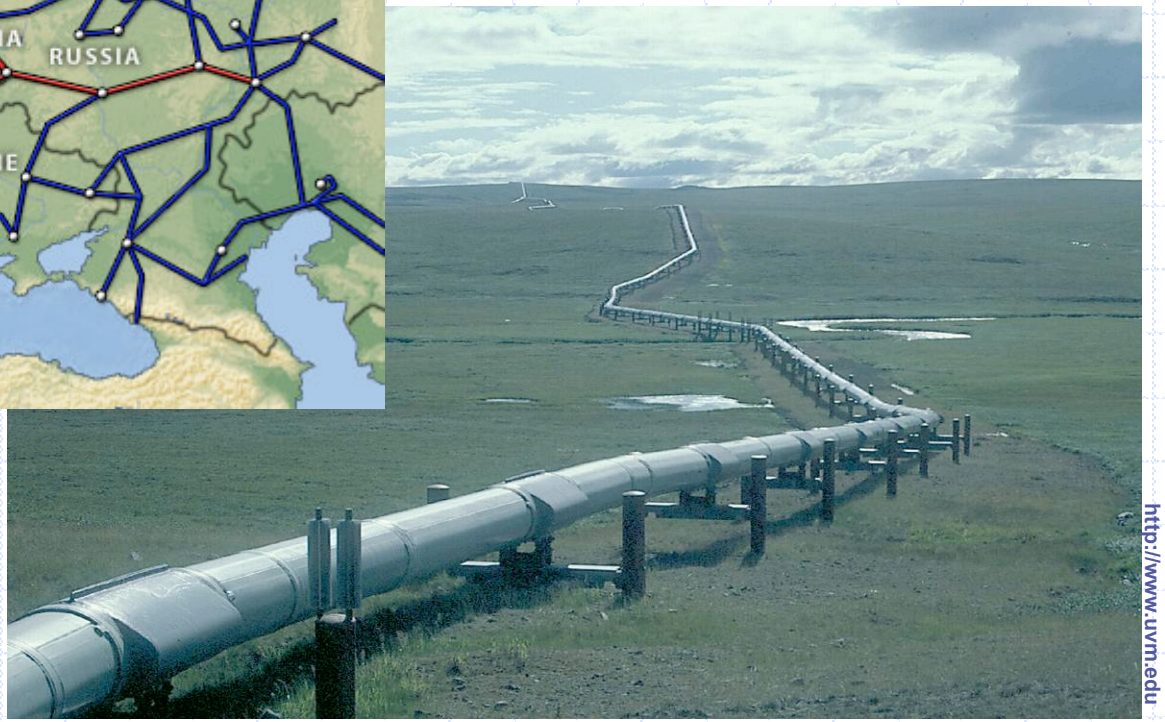
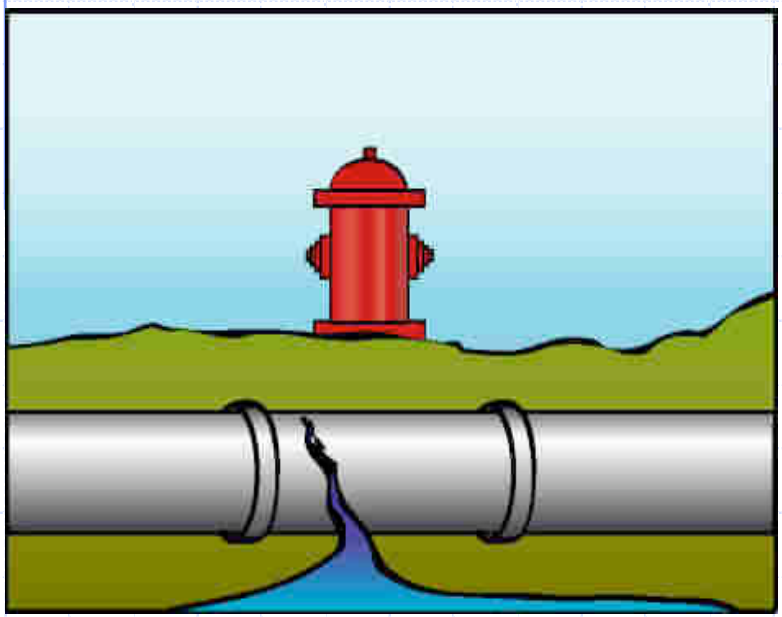
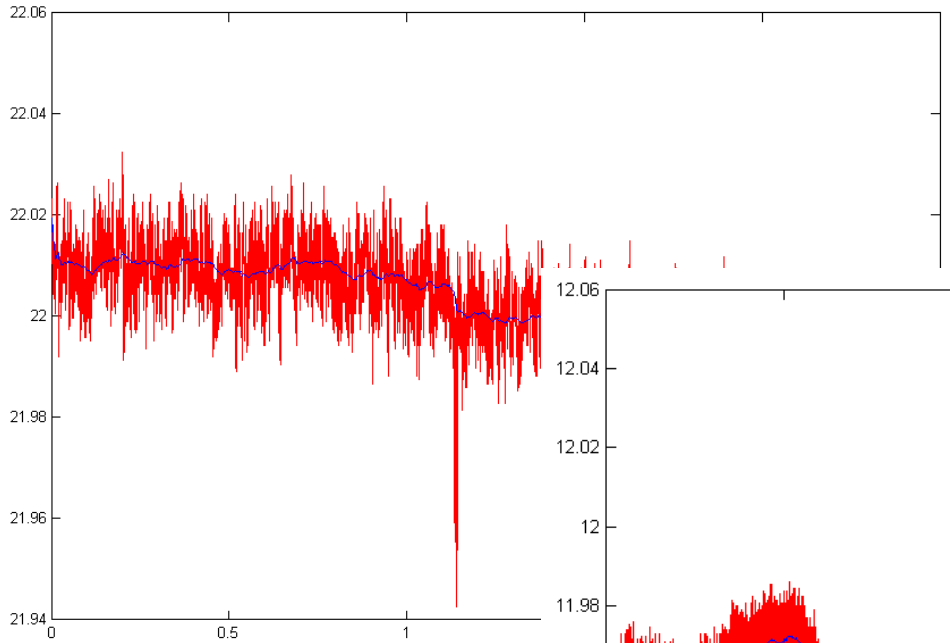


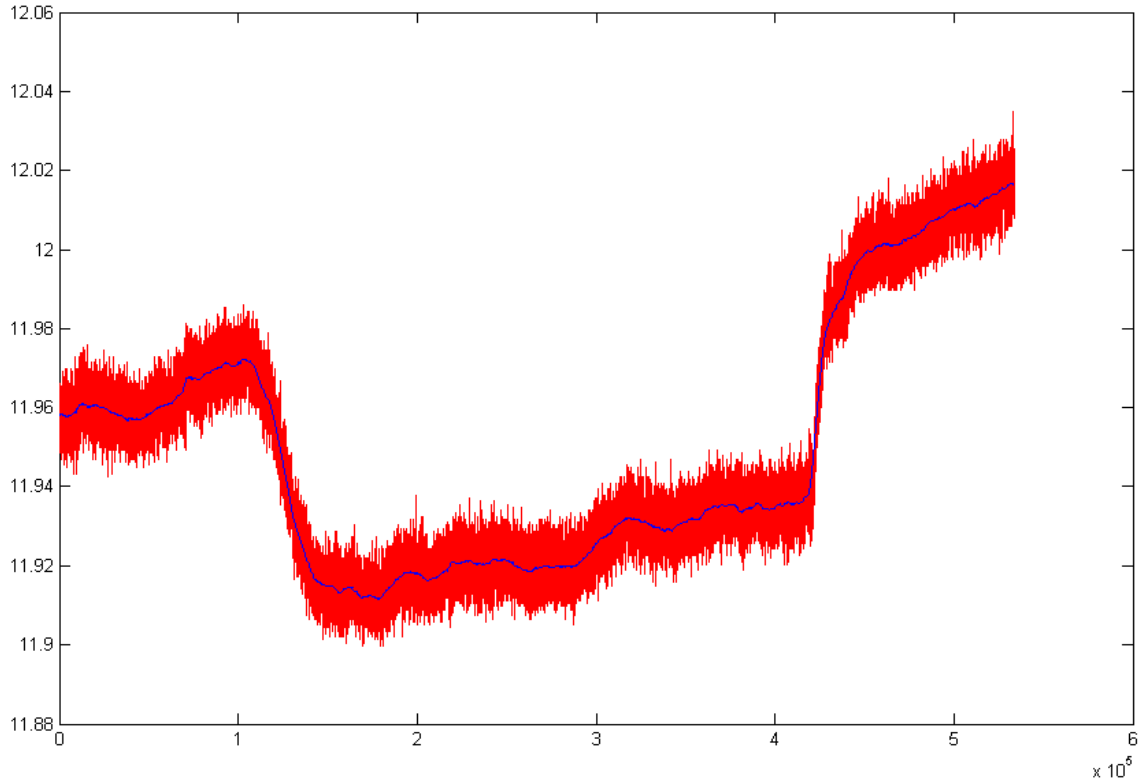
http://www.uvm.edu

# Pressure oscillations in pipelines

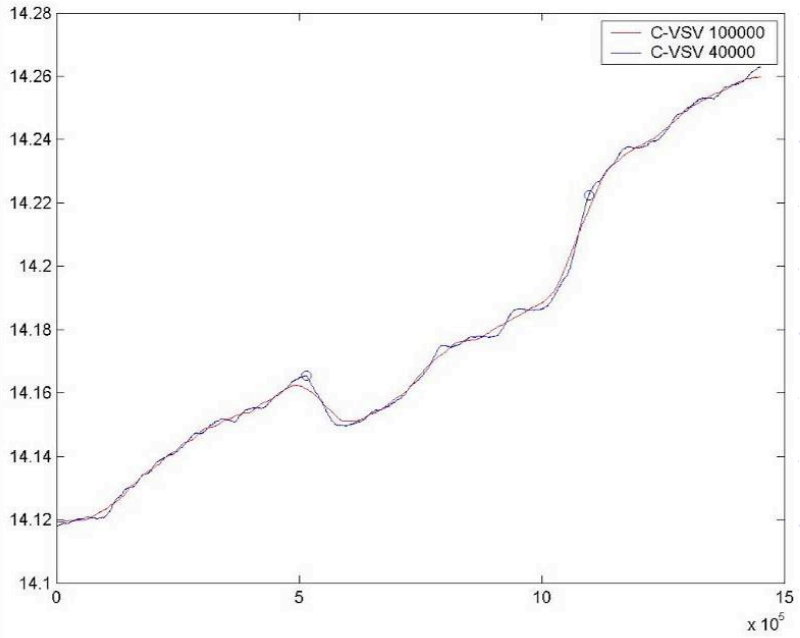


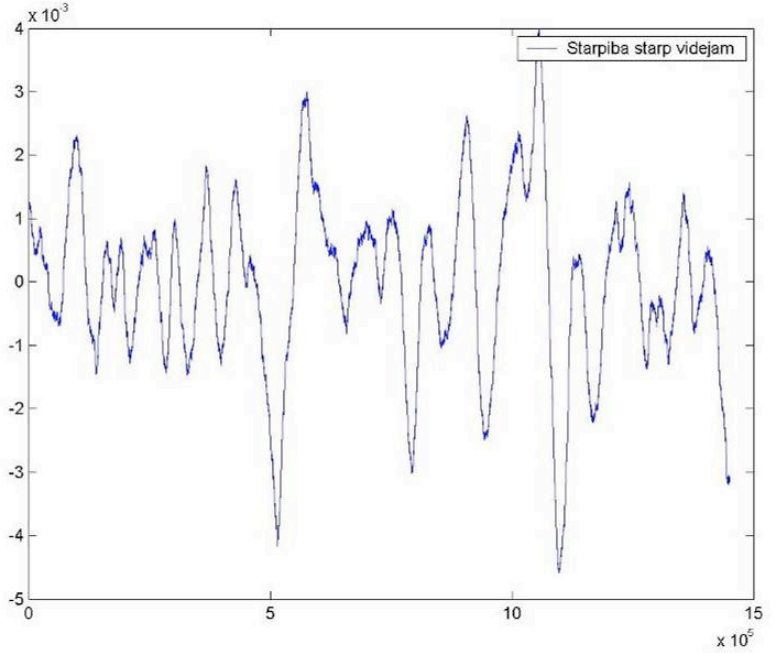
# The initial task formulation



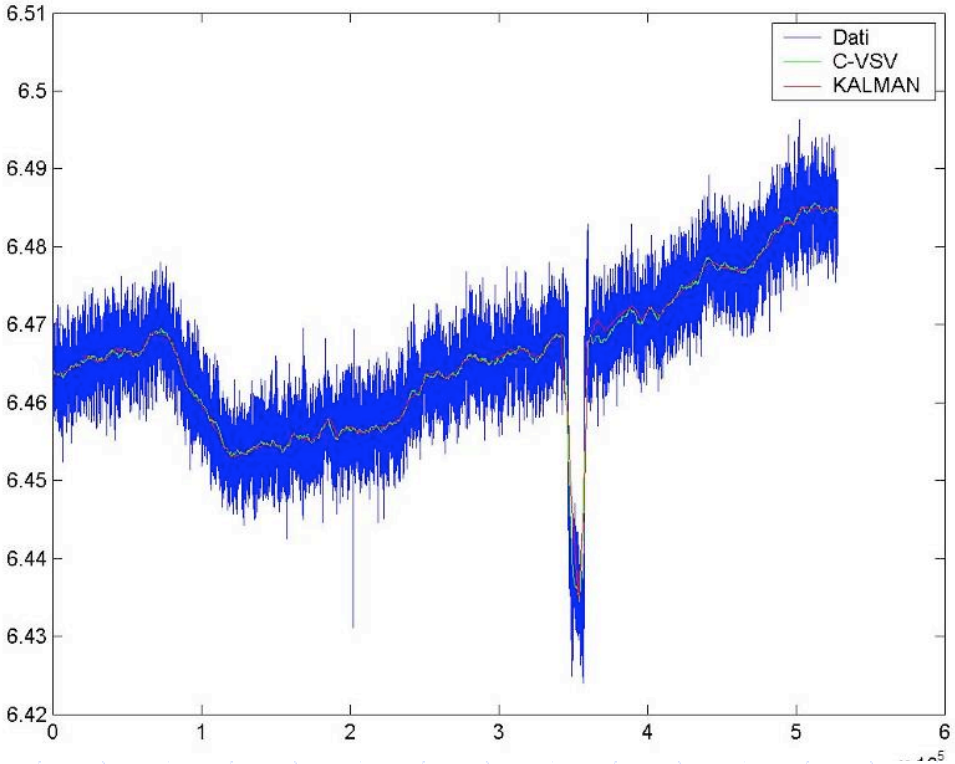



# (*Moving Average Convergence Divergence*, MACD)



# Kalman filtering




$$Y_1 = aY_0 + w_0,$$

$$x_1 = hY_1 + v_1,$$

$$y_1^- = aY_0,$$

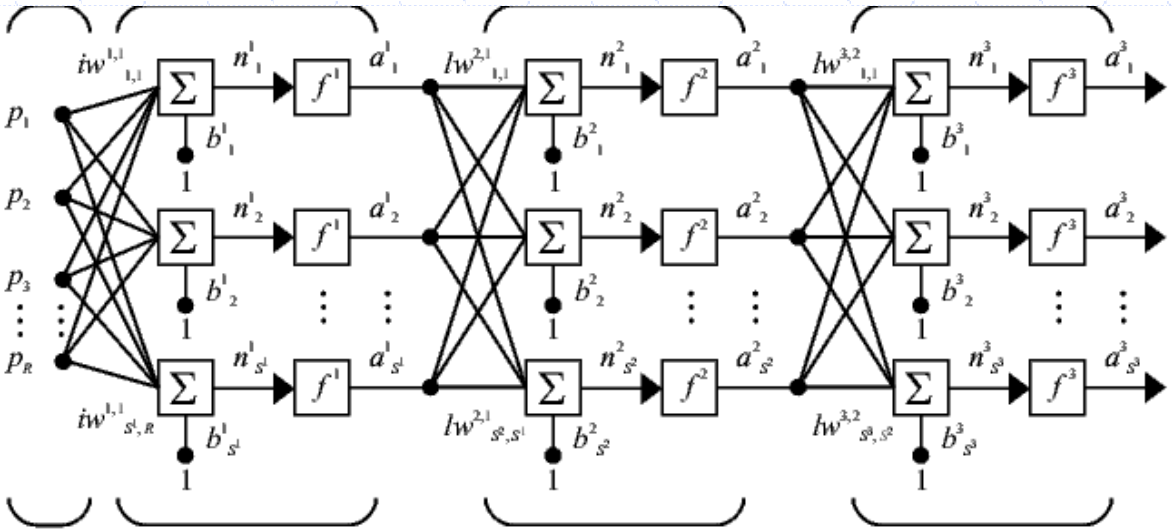
$$P_1^- = a^2 P_0,$$

$$K_1 = \frac{hP_1^-}{h^2 P_1^- + R},$$

$$P_1 = P_1^-(1 - hK_1)^2 + RK_1^2,$$

$$y_1 = y_1^- + K_1(x_1 - hy_1^-).$$

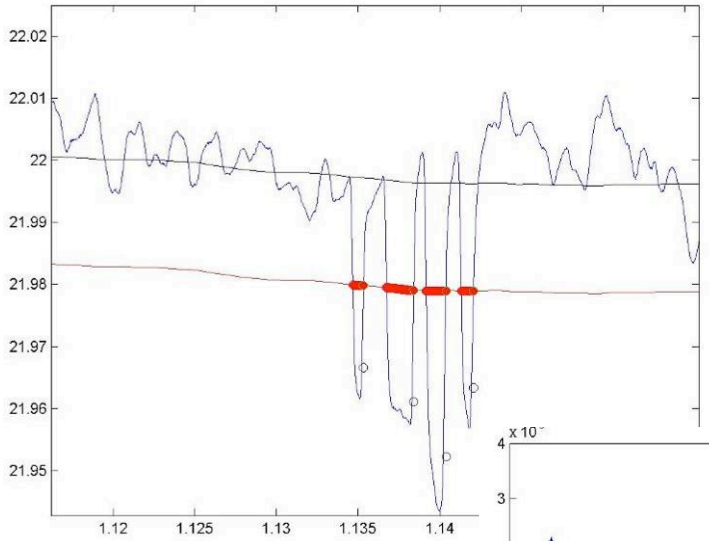
# Neural networks

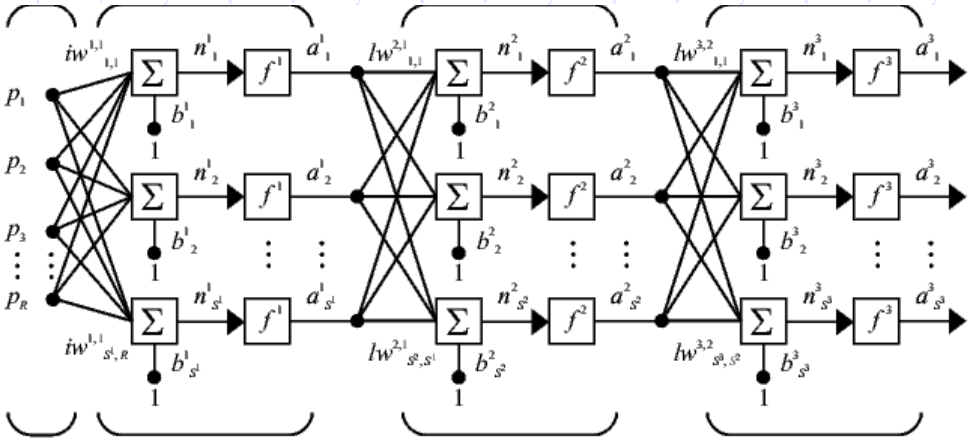


$$\mathbf{a}^1 = \mathbf{f}^1(\mathbf{IW}^{1,1}\mathbf{p} + \mathbf{b}^1) \qquad \mathbf{a}^2 = \mathbf{f}^2(\mathbf{LW}^{2,1}\mathbf{a}^1 + \mathbf{b}^2) \qquad \mathbf{a}^3 = \mathbf{f}^3(\mathbf{LW}^{3,2}\mathbf{a}^2 + \mathbf{b}^3)$$

$$\mathbf{a}^3 = \mathbf{f}^3(\mathbf{LW}^{3,2}\mathbf{f}^2(\mathbf{LW}^{2,1}\mathbf{f}^1(\mathbf{IW}^{1,1}\mathbf{p} + \mathbf{b}^1) + \mathbf{b}^2) + \mathbf{b}^3)$$

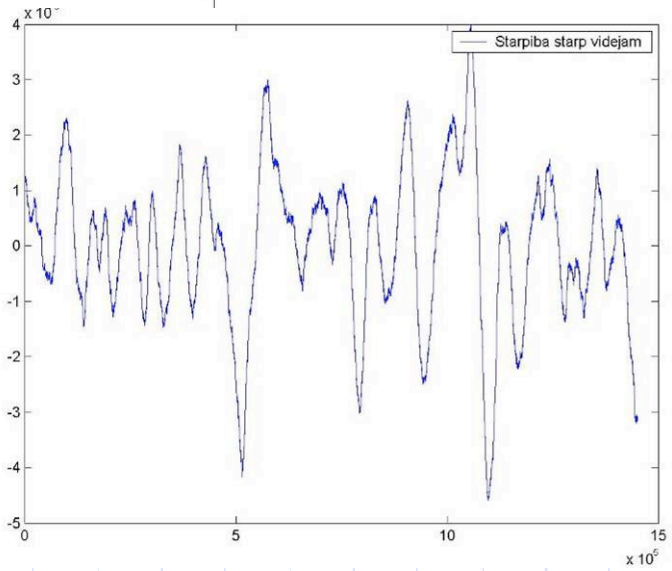
# NN-identification



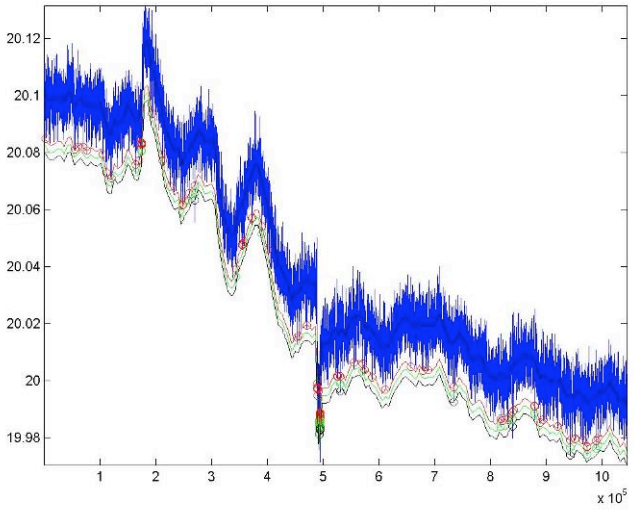
$$a^2 = f^2(LW^{2,1}a^1 + b^2) \qquad a^3 = f^3(LW^{3,2}a^2 + b^3)$$

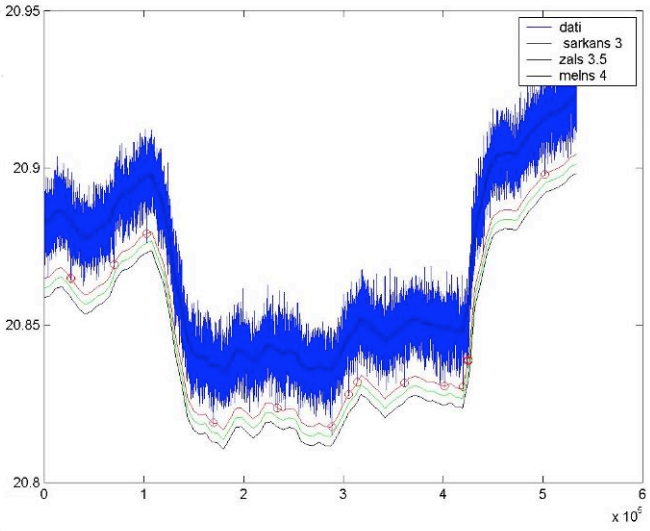
$$a^3 = f^3(LW^{3,2}f^2(LW^{2,1}f^1(IW^{1,1}p + b^1) + b^2) + b^3)$$

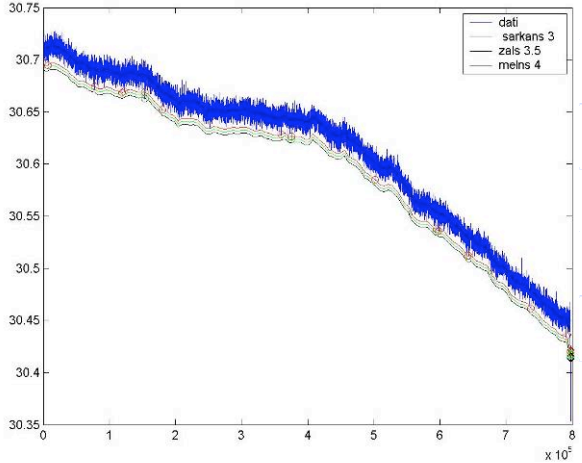


# The testing procedure

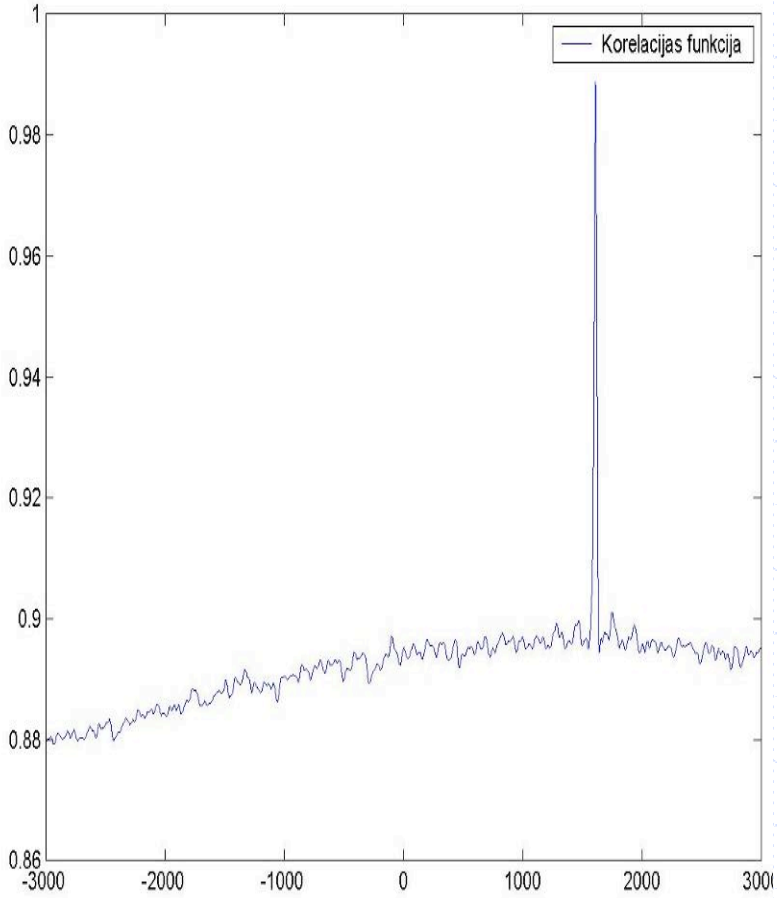
Algorithms should be tested in different situations

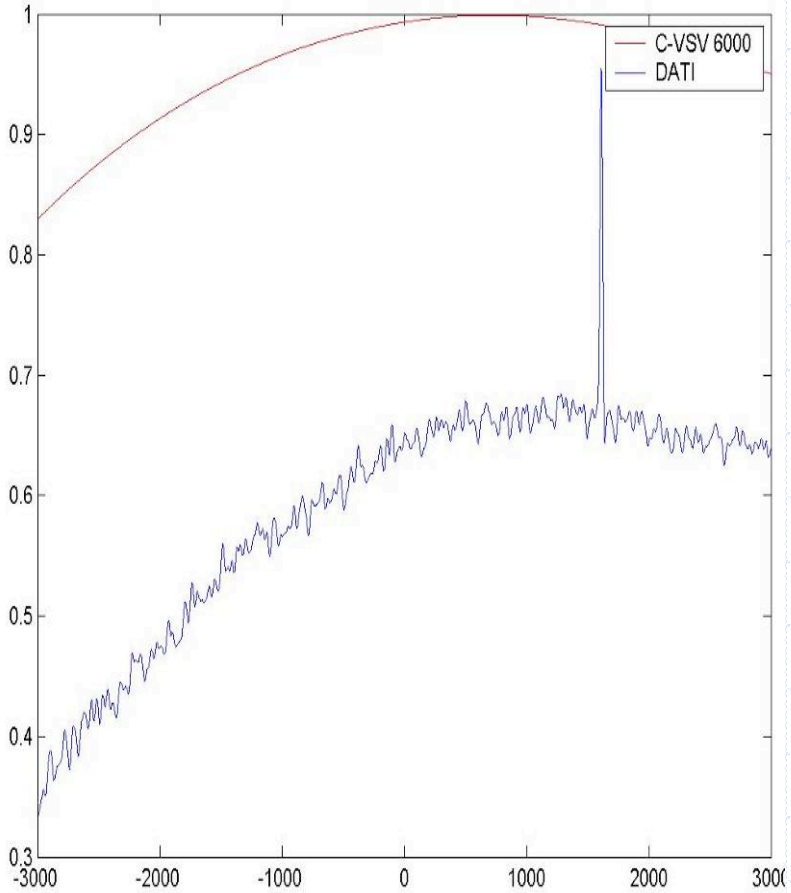


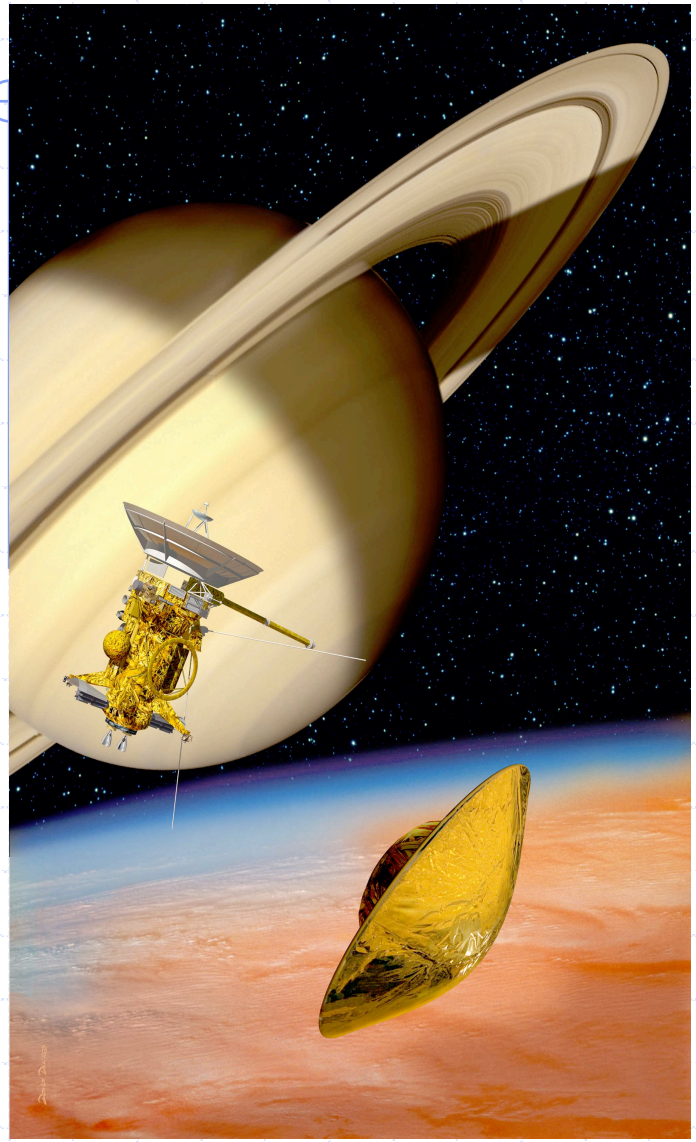
# Exact leak identification




United States
France
Germany
Belgium
Italy
Denmark
United Kingdom
Switzerland
Netherlands
Czech Republic
Austria
Spain
Finland
Ireland
Hungary
Sweden
Norway
International Participation in
CASSINI
Saturn Orbiter and Huygens Titan Probe

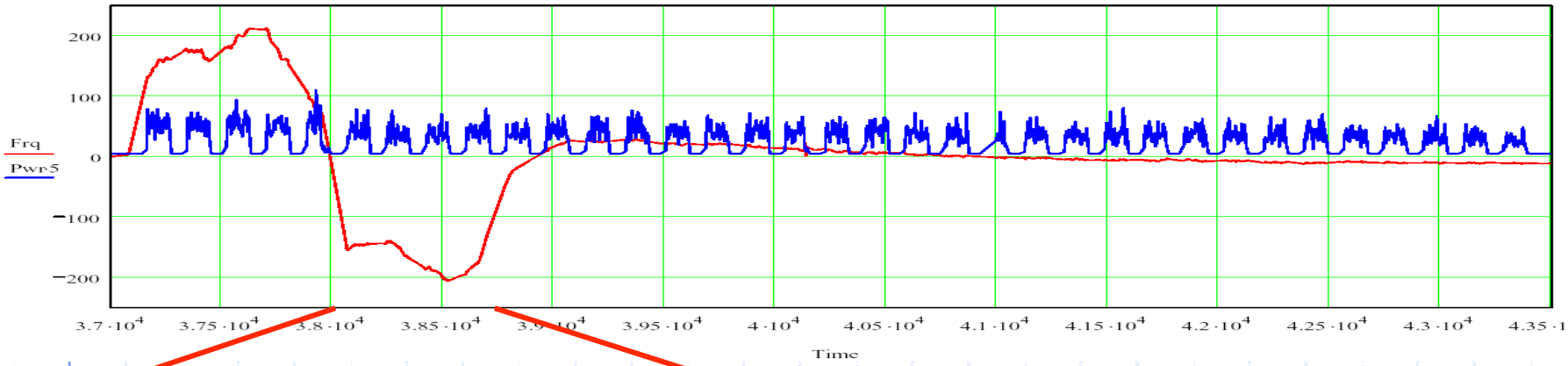
# Exact measurements in radioastronomy: Cassini – Huygents mission

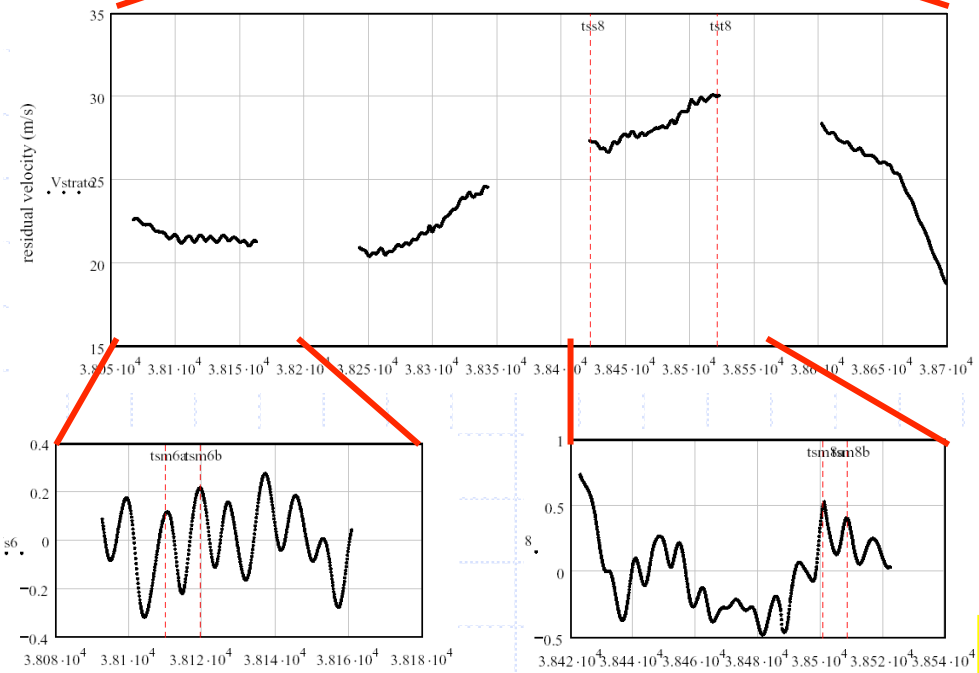


*Christiaan Huygens*

*Giovanni Domenico Cassini*


CASSINI
MISSION TO SATURN
CASSINI

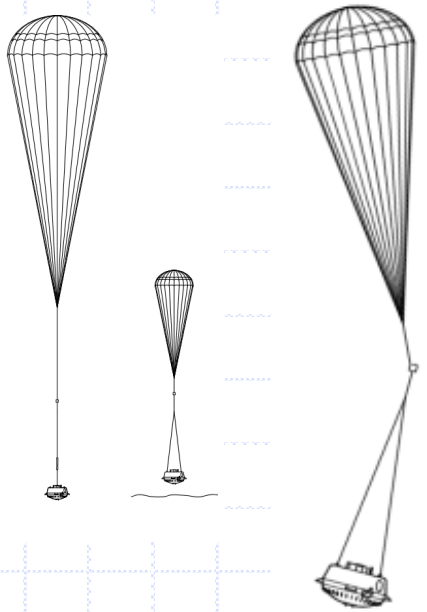



$T = 8 \div 10$ s

$\Delta V = 0.22$ m/s

$A \approx 0.6$ m

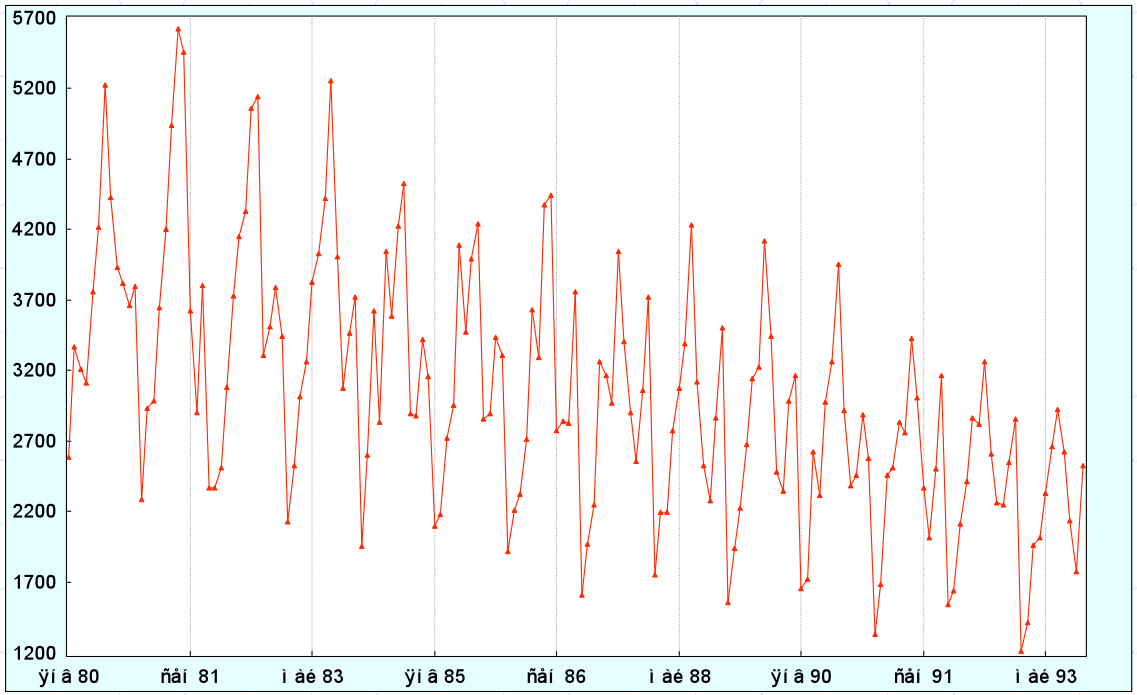


**Need for further joint analysis!**

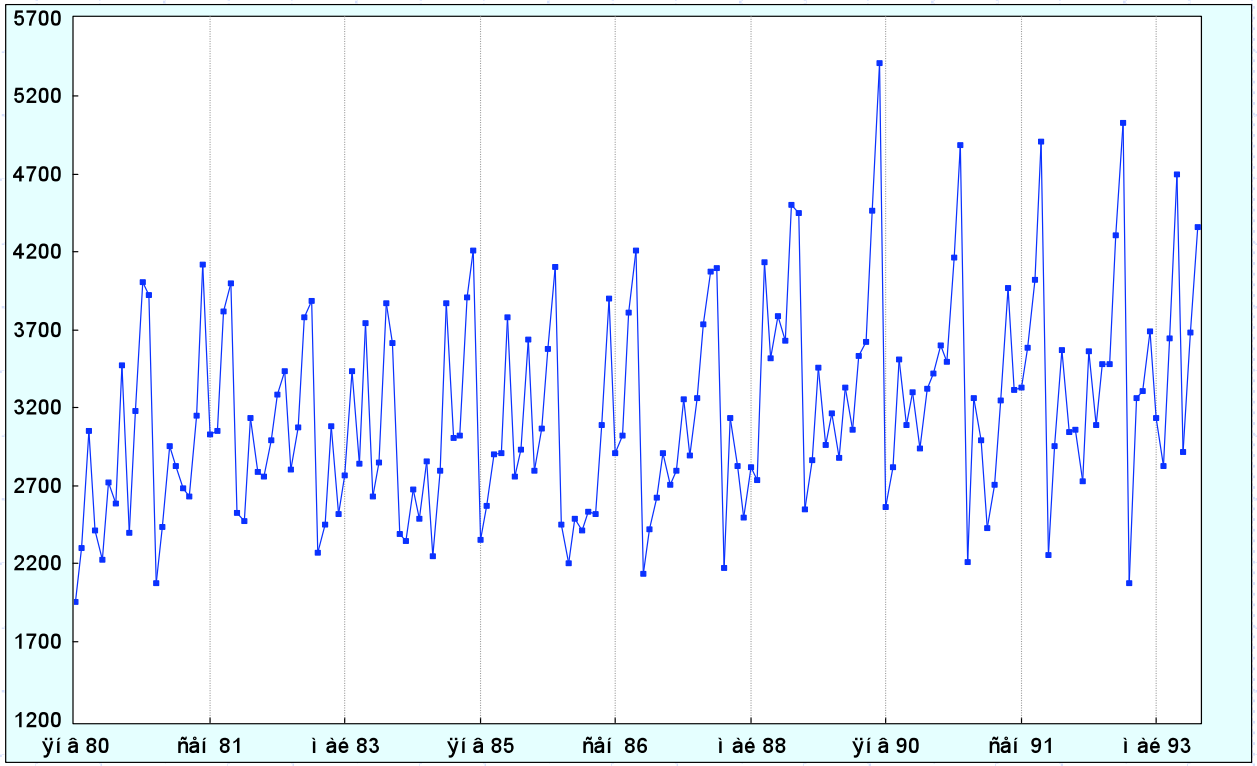
# Forecasting in marketing: vine sells in Australia

**FORT and DRY time series which describe vine sells volumes in Australia from January 1980 until November 1993 (N=167) in thousands of liters.**

# FORT (strong vine)



# DRY (dry vine)


5700
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ÿí â 80
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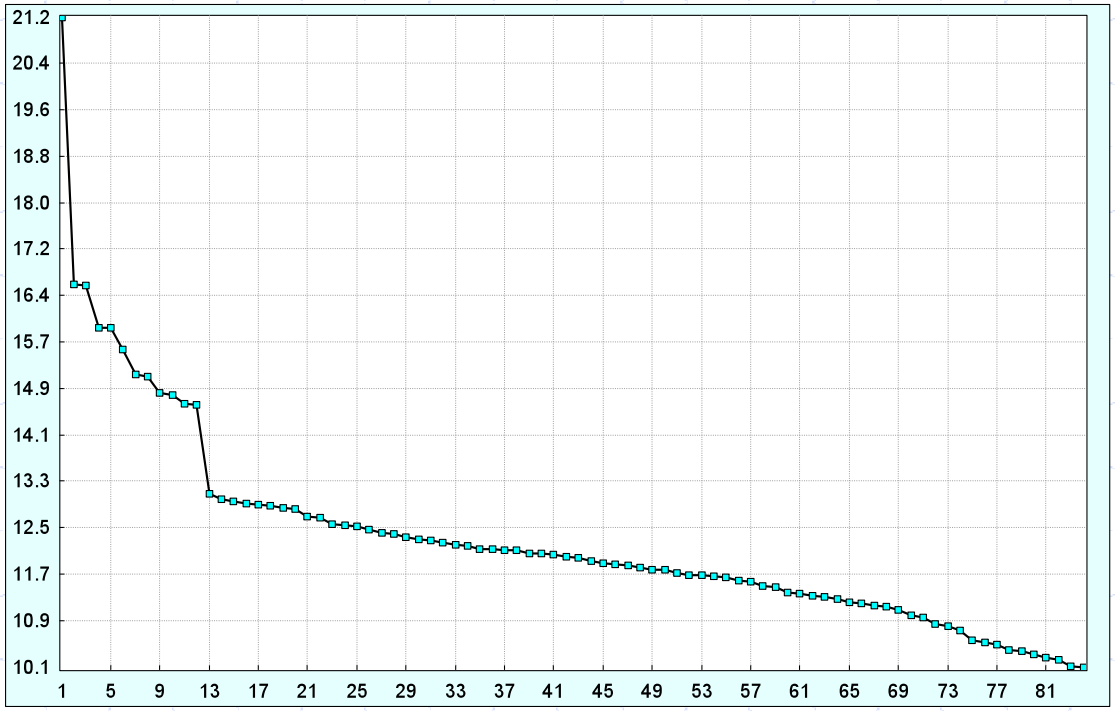
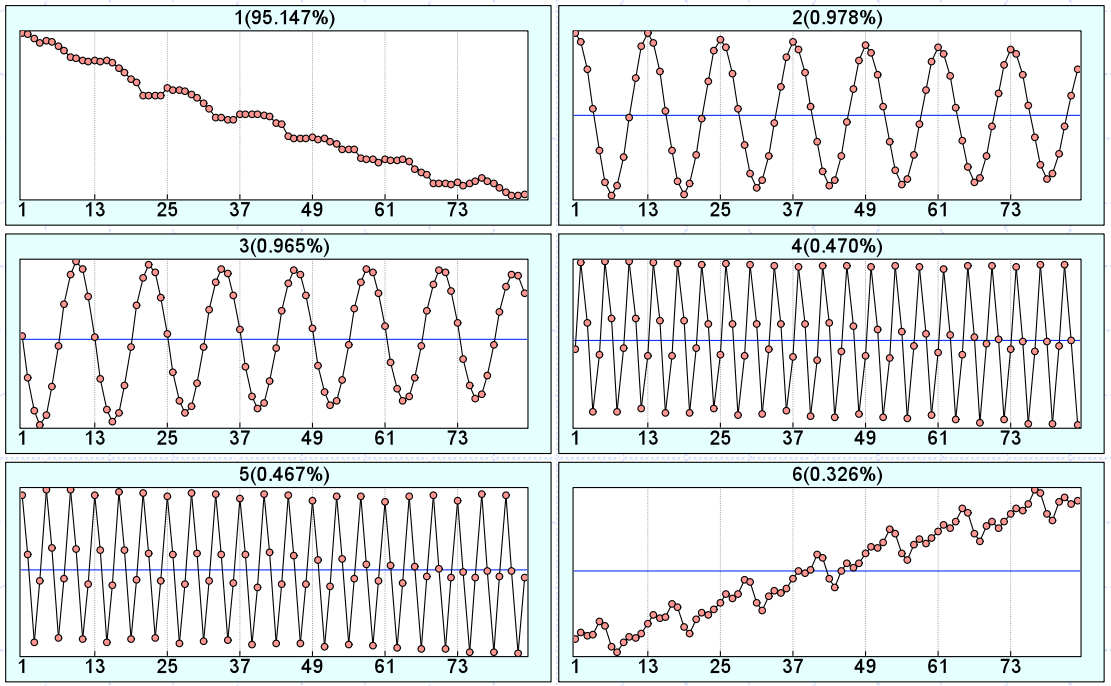
ÿí â 90
ñåí 91
ì àé 93

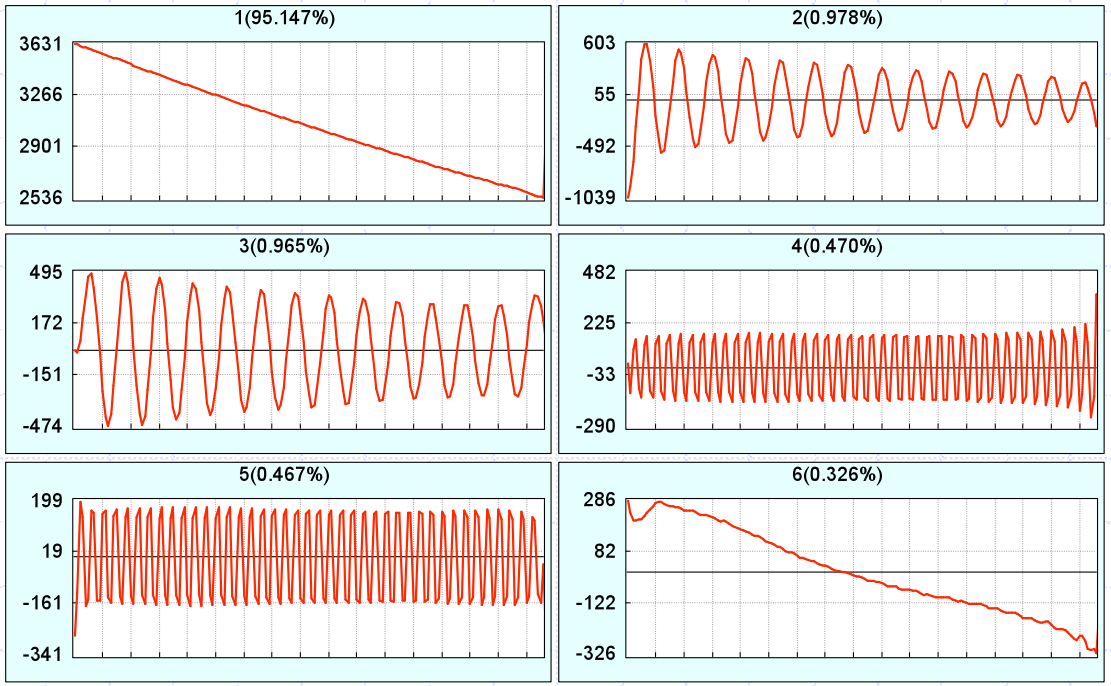
# Singular Spectral Analysis (SSA): eigevalues



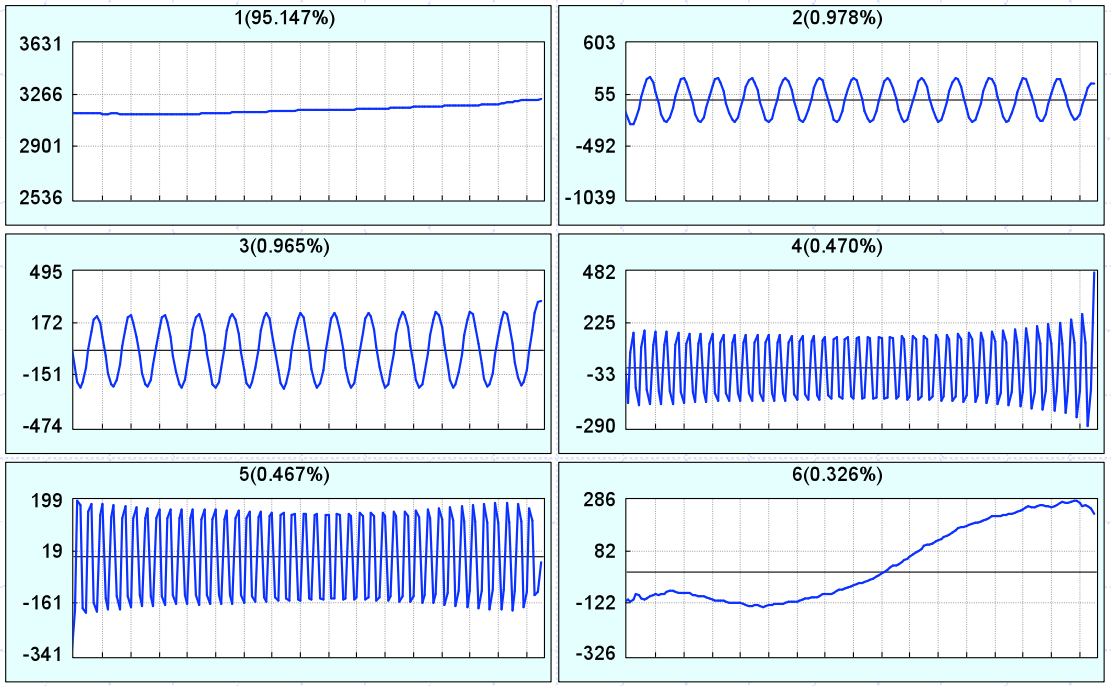
# SSA: components



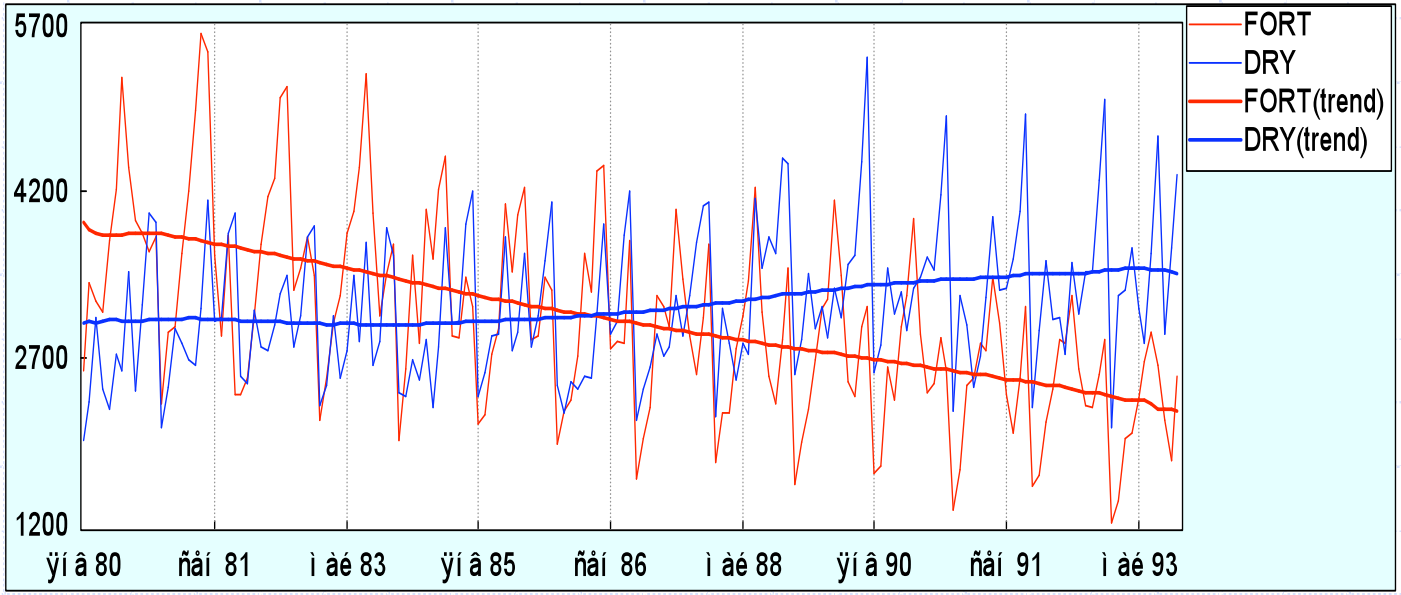
# SSA – FORT components



# SSA: DRY components



# SSA: trends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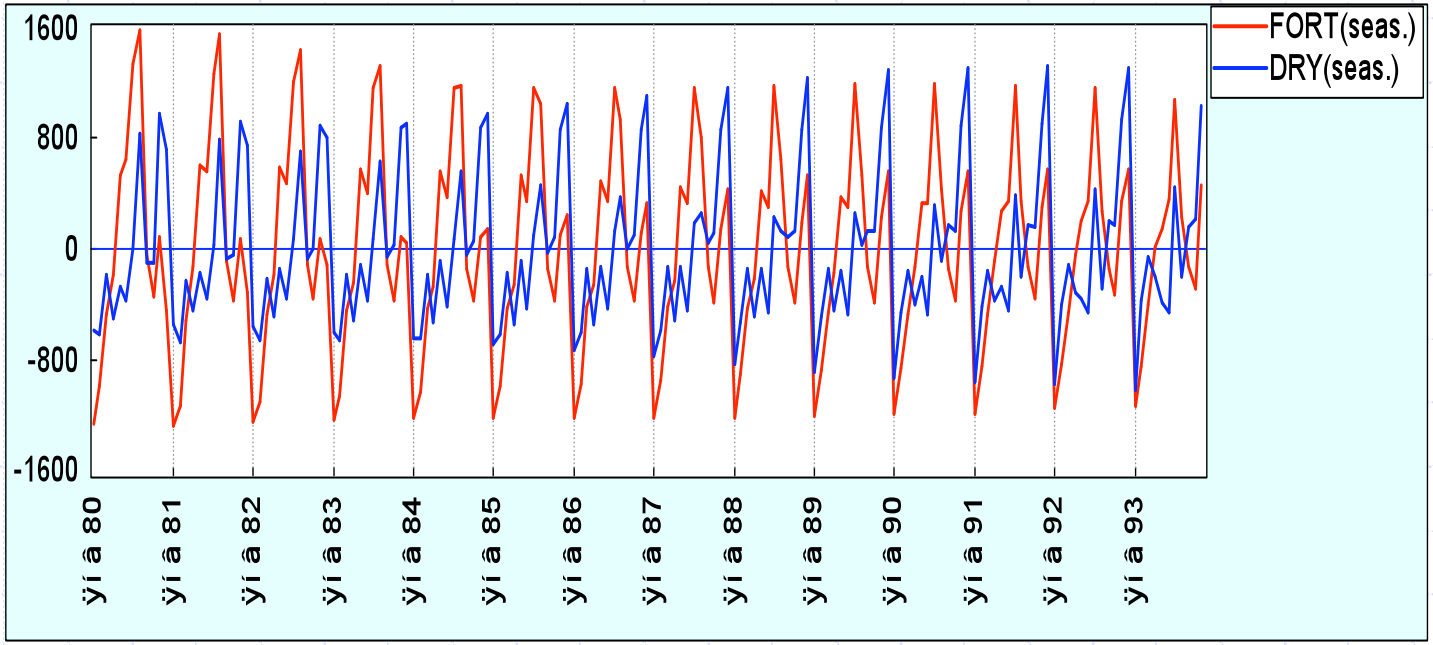
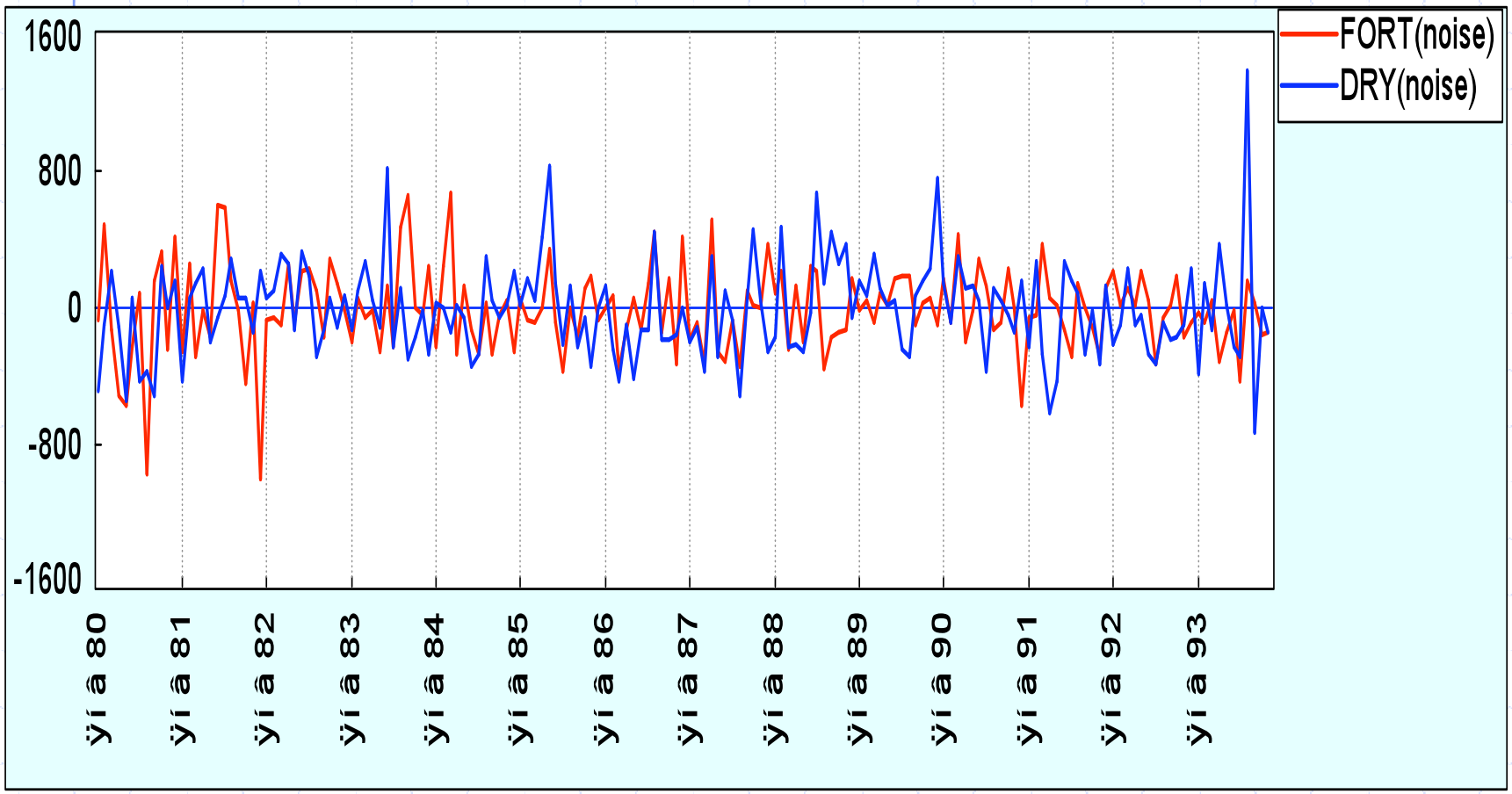
ñåí 86
ì àé 88
ÿí â 90
ñåí 91
ì àé 93
FORT
DRY
FORT(trend)
DRY(trend)

## SSA: season components



## SSA: noise


1600
800
0
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-1600
FORT(noise)
DRY(noise)
ÿí â 80
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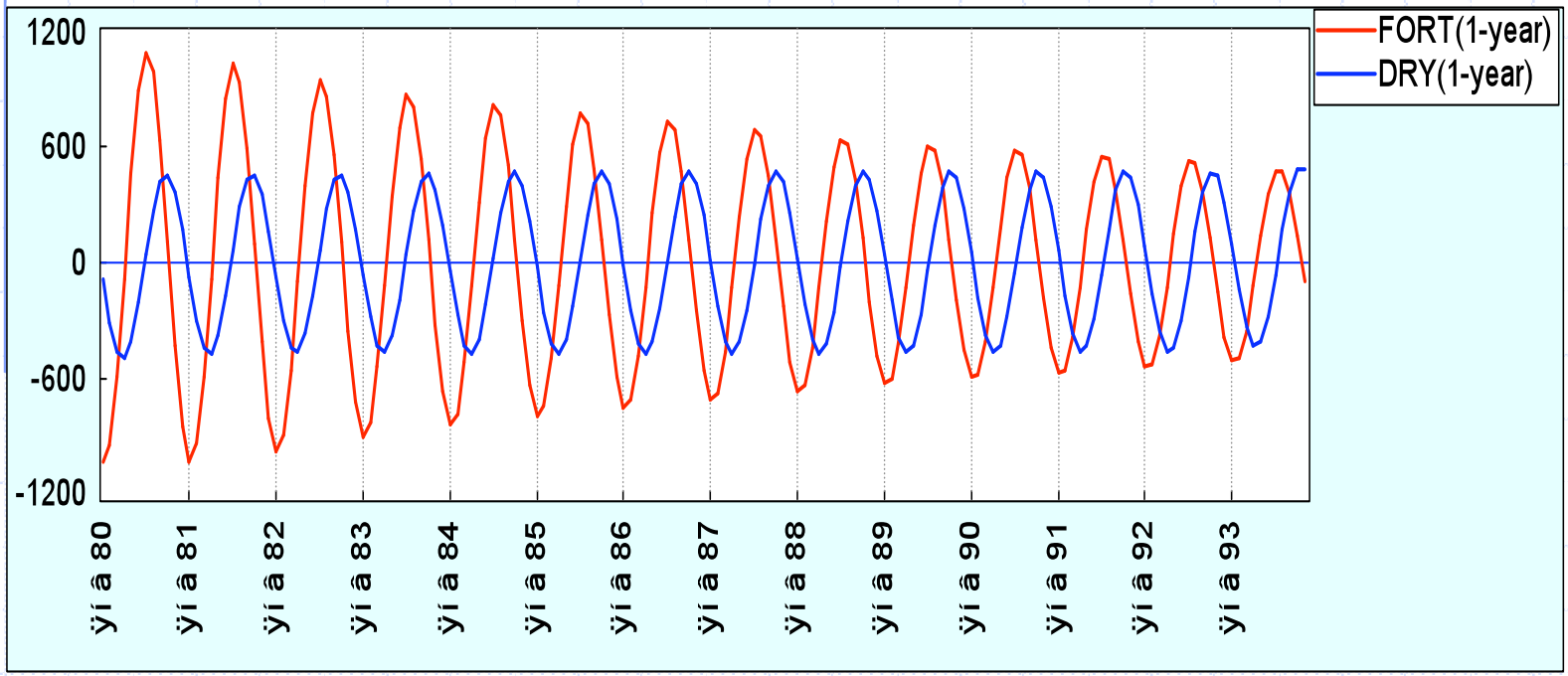
ÿí â 92
ÿí â 93

## SSA: year forecast



# Literature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2. Broomhead D.S., King G.P. On the qualitative analysis of experimental dynamical systems // Nonlinear Phenomena and Chaos / Ed. by S. Sarkar. Bristol: Adam Hilger. 1986. P. 113-144.
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12184: TradeXecutioner - Демо Счет - [EURUSD,H1]
Файл Вид Вставка Графики Сервис Окно Справка
Новый Ордер
Советники
M1 M5 M15 M30 H1 H4 D1 W1 MN
EURUSD,H1 1.2996 1.2998 1.2990 1.2991
EMA_CROSS_2_RonModV7a
#534972 buy
1.3365
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USDJPY,H4 | USDCHF,H1 | GBPUSD,H4 | GOLD,M30 | EURUSD,H1
Ордер | Время | Тип | Лоты | Символ | Цена | S / L | T / P | Цена | Комиссия | Своп | Прибыль
534972 | 2007.01.09 21:07 | buy | 0.50 | eurusd | 1.3008 | 1.2940 | 1.3050 | 1.2991 | 0.00 | -5.65 | -85.00
Баланс: 9 978.00 Средства: 9 887.35 Залог: 650.40 Свободно: 9 236.95 Уровень: 1520.20% -90.65
Терминал
Торговля | История Счета | Новости | Сигналы | Почтовый ящик | Эксперты | Журнал
Для справки, нажмите F1
Default
2006.12.28 14:00
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L: 1.3148
C: 1.3169
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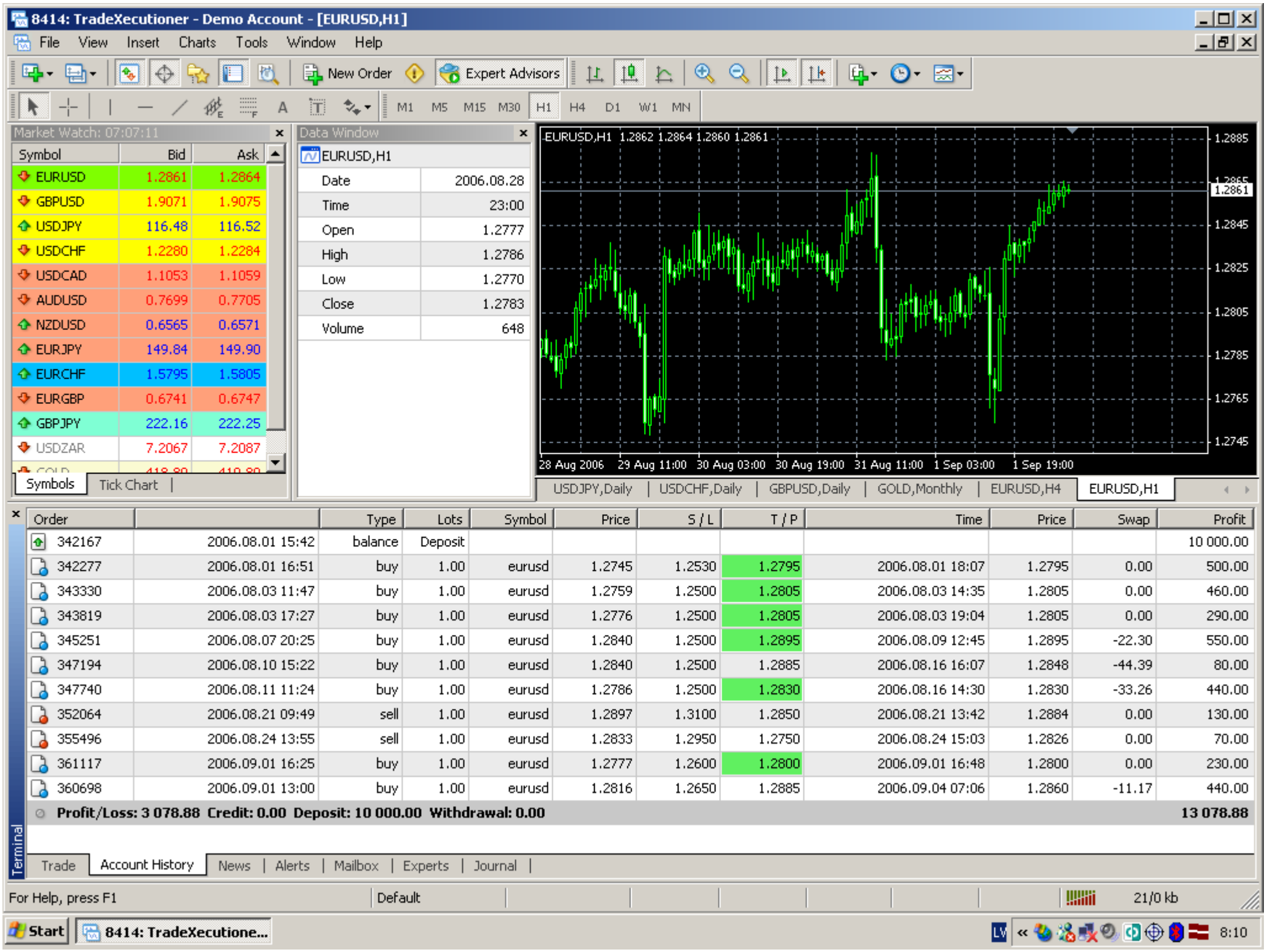
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New Order
Expert Advisors
M1 M5 M15 M30 H1 H4 D1 W1 MN
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USDCHF 1.2280 1.2284
USDCAD 1.1053 1.1059
AUDUSD 0.7699 0.7705
NZDUSD 0.6565 0.6571
EURJPY 149.84 149.90
EURCHF 1.5795 1.5805
EURGBP 0.6741 0.6747
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USDZAR 7.2067 7.2087
Symbols Tick Chart
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Low 1.2770
Close 1.2783
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28 Aug 2006 29 Aug 11:00 30 Aug 03:00 30 Aug 19:00 31 Aug 11:00 1 Sep 03:00 1 Sep 19:00
USDJPY,Daily USDCHF,Daily GBPUSD,Daily GOLD,Monthly EURUSD,H4 EURUSD,H1
Order Type Lots Symbol Price S / L T / P Time Price Swap Profit
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343330 2006.08.03 11:47 buy 1.00 eurusd 1.2759 1.2500 1.2805 2006.08.03 14:35 1.2805 0.00 460.00
343819 2006.08.03 17:27 buy 1.00 eurusd 1.2776 1.2500 1.2805 2006.08.03 19:04 1.2805 0.00 290.00
345251 2006.08.07 20:25 buy 1.00 eurusd 1.2840 1.2500 1.2895 2006.08.09 12:45 1.2895 -22.30 550.00
347194 2006.08.10 15:22 buy 1.00 eurusd 1.2840 1.2500 1.2885 2006.08.16 16:07 1.2848 -44.39 80.00
347740 2006.08.11 11:24 buy 1.00 eurusd 1.2786 1.2500 1.2830 2006.08.16 14:30 1.2830 -33.26 440.00
352064 2006.08.21 09:49 sell 1.00 eurusd 1.2897 1.3100 1.2850 2006.08.21 13:42 1.2884 0.00 130.00
355496 2006.08.24 13:55 sell 1.00 eurusd 1.2833 1.2950 1.2750 2006.08.24 15:03 1.2826 0.00 70.00
361117 2006.09.01 16:25 buy 1.00 eurusd 1.2777 1.2600 1.2800 2006.09.01 16:48 1.2800 0.00 230.00
360698 2006.09.01 13:00 buy 1.00 eurusd 1.2816 1.2650 1.2885 2006.09.04 07:06 1.2860 -11.17 440.00
Profit/Loss: 3 078.88 Credit: 0.00 Deposit: 10 000.00 Withdrawal: 0.00 13 078.88
Terminal
Trade Account History News Alerts Mailbox Experts Journal
For Help, press F1
Default
21/0 kb
Start
8414: TradeXecutione...
8:10

# Mathematical problems in DSP

1. There is a lot of complicated mathematics in DSP.
2. There is a whole set of mathematical methods of different complexities, which can solve the same task (noise filtering, for example) with different degrees of exactness.
3. The simplest way to extract signal from noise is to use moving averages. More complicated is Kalman filtering. More complicated is singular spectral analysis.
4. Weak methods are simple, effective methods are complicated.
5. It is interesting to start signal analysis from simplest methods and consequently improve them to receive better and better results until algorithm became efficient enough to reach necessary exactness.
6. Possibility to compare results of simple methods with results of complicated methods is useful for explanation of complicated methods necessity. It is possible to demonstrate in clear way, that sometimes there are no other ways to solve problem than to use complicated methods.

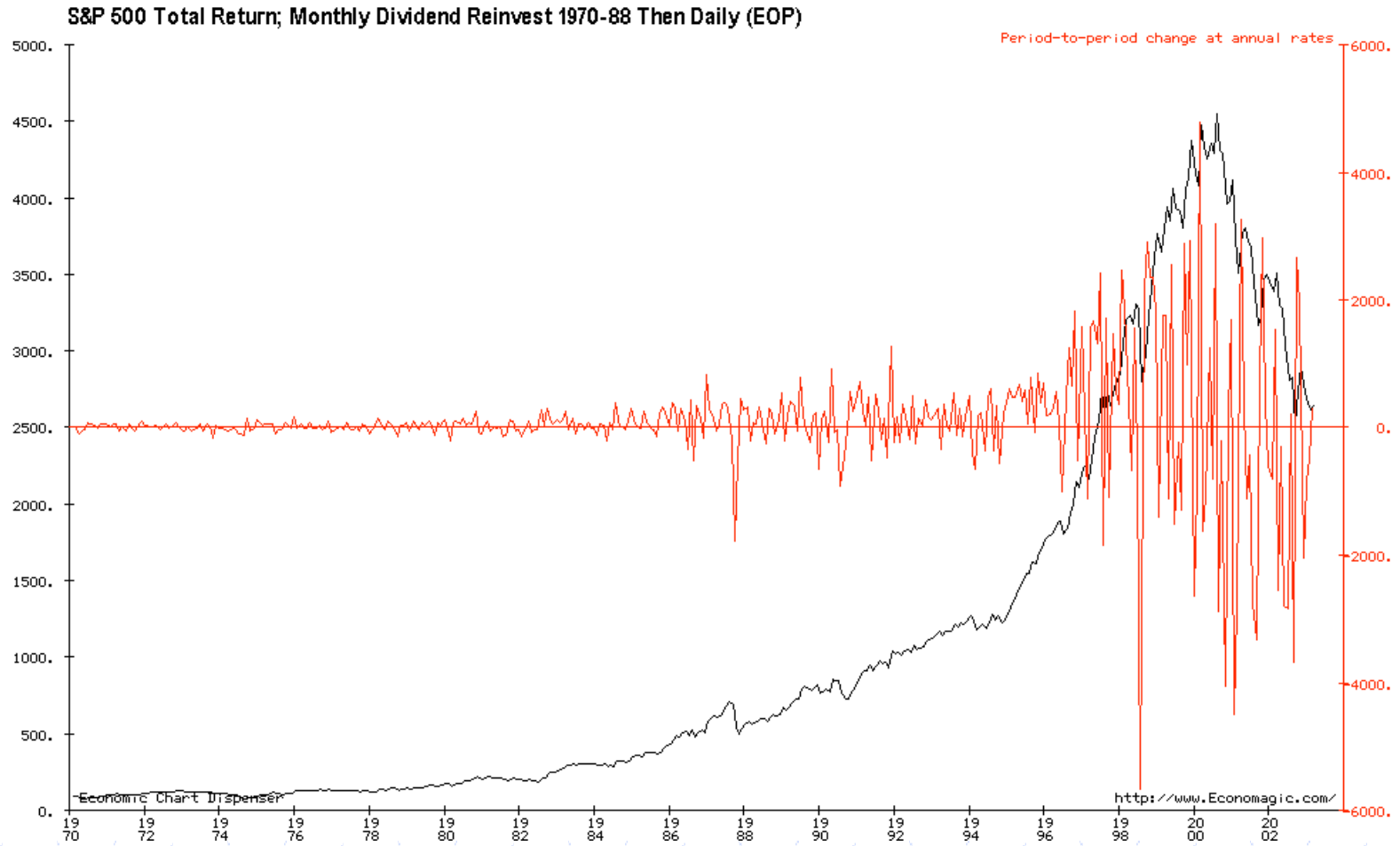
# DSP software

1. There is a lot of software for DSP
2. We recommend to start from standard MATLAB DSP Toolbox
3. There is a set specialized packages
4. There are tasks, that can not be solved with standard tools and in such cases it is necessary to realize appropriate DSP algorithms by direct programming.

# Conclusions

**All above mentioned and whole set of others properties makes DSP as a very attractive tool for IT students education. Ventspils University College has certain experience in DSP implementation for different practical tasks solving, including industrial mathematics, space technologies, financial mathematics, and uses it for IT student's education to ensure close contacts with the needs of business and industry.**

# Current situation: need for the stable relations in unstable world



# Thank you for your attention!