Library of Mathematical Transforms over Algorithms of Spectral-Analytical Data Processing

Applications in data analysis and pattern recognition

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Methods

- **Generalized Spectral-Analytical Method (GSAM) as extrapolation of classical Fourier series to a wider class of basic approximating functions**
- **Parallel, recurrent and iterative algorithms of data analysis and transforms**

Applications

- **Processing of biomechanical experiments data, the control of human state by means of body movements analysis (possible use for driver state recognition)**
- **Data analysis and diagnosis in electrophysiology (gastrology, cardiology, encephalography)**
- **Analysis of magnetic encephalography data – the brain functional charting and pathology states control**
- **Spectral methods of biological macromolecules analysis - genetic sequences, primary and spatial structures of proteins**
- **Data analysis and recognition in the space surveillance systems**
- **Monitoring and Diagnostics in the Technical imaging**
- **Data analysis, modeling and forecasting in the transportation acoustic ecology**

Cooperation

- **Russian Academy of Sciences –**
  - ✓**Institute of Biophysics**
  - ✓**Institute of Protein Researches**
  - ✓**Dorodnicyn Computing Centre**
  - ✓**Blagonravov Institute of Machines Science**
  - ✓**Kotel'nikov Institute of Radio-engineering and Electronics**
- **Lomonosov Moscow State University**
- **Federal Space Agency**
- **Russia Tunneling Association**
- **Moscow SubWay Administration**
- **Prague Technical University**
- **New York University**
- **Berlin Technical University**

Grants

- **Russian Foundation for Basic Researches**
- **U.S. Civilian Research and Development Foundation**

Publications

F. F. Dedus, S. A. Makhortykh, M. N. Ustinin, and A. F. Dedus. Generalized Spectral-Analytic Method for Data Processing," in Problems in Image Analysis and Pattern Recognition (Mashinostroenie, Moscow, 1999) [in Russian], 356 p.

F.F.Dedus, S.A.Makhortykh and M.N.Ustinin. Generalized Spectral-Analytic Method in Information Processing Problems. *Pattern Recognition and Image Analysis*, 2002, vol.12, N 4, pg.429-437.

A. N. Pankratov, S. A. Makhortykh, et al. Spectral Analysis for Identification and Visualization of Repeats in Genetic Sequences. Pattern Recognition and Image Analysis, 2009, Vol. 19, No. 4, pp. 687-692.

S. Makhortykh, E. Lyzhko. Sources localization for brain biomagnetic activity. *Review of Applied Physics (RAP)*, 2014, vol.3, pg.25-28.

S.A.Kostarev, S.A.Makhortykh, S.A.Rybak. Calculations of ground vibrations induced by underground sources: analytical and numerical approaches, In: Noise and vibration from high-speed trains. London, Thomas Telford Publishing, 2001, pg. 397-422.

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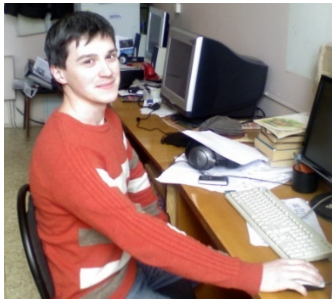
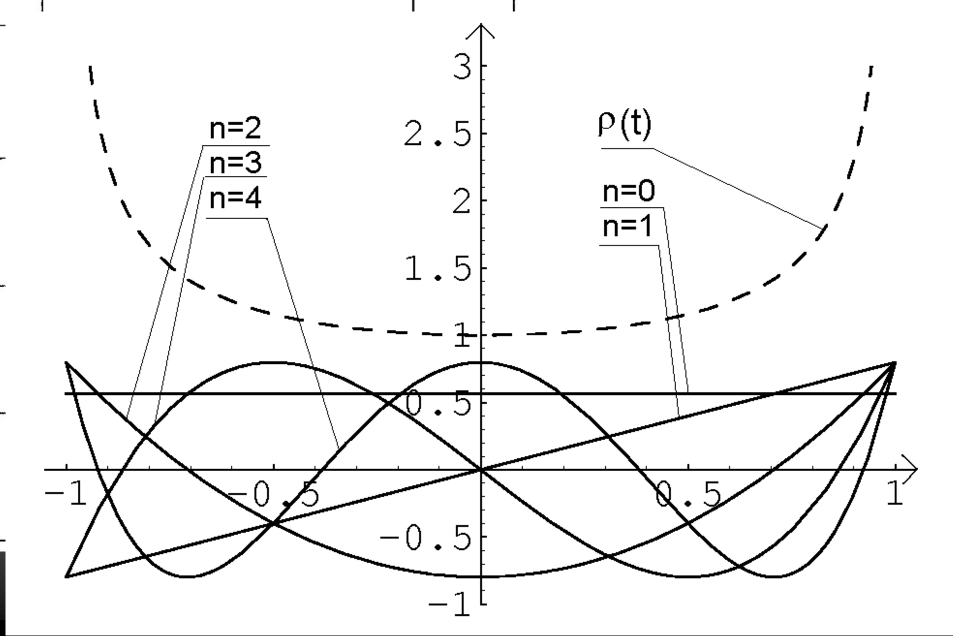


Classical orthogonal polynomials

Table 1. Classical orthogonal polynomials

No.	Polynomial	Symbol	General expression	Weight $p(x)$	Limits of existence	
					Lower	Upper
1	Jacobi or hypergeometric	$P_n^{\alpha\beta}(x)$	$P_n^{\alpha\beta}(x) = \frac{1}{2n}\sum_{k=0}^{n} C_n^k \frac{\Gamma(\alpha+n+1)\,\Gamma(\beta+n+1)}{\Gamma(\alpha+k+1)\,\Gamma(\beta+n+k+1)}(x-1)^k(x+1)^{n-k}$	$(1-x)^\alpha(1+x)^\beta$ $\alpha > -1 \quad \beta > -1$	−1	+1
2	Gegenbauer of ultraspherical	$C_n^\sigma(x)$	$C_n^\sigma(x) = \sum_{k=0} \frac{(-1)^k\Gamma(\alpha+n-k)}{\Gamma(k+1)\,\Gamma(n-2k+1)}(2x)^{n-2k}$	$(1-x^2)^{\sigma-0.5}$ $\alpha=\beta=\sigma-0.5$	−1	+1
3	Chebyshev of the first kind	$T_n(x)$	$T_n(x) = \frac{2^n n!}{(2n)!}\sqrt{x^2-1}\frac{d^n}{dx^n}[(x^2-1)^{n-2k}]$	$(1-x^2)^{-0.5}$ $\alpha=\beta=-0.5$	−1	+1
4	Chebyshev of the second kind	$U_n(x)$	$U_n(x) = \frac{2^n(n+1)!}{(2n+1)!\sqrt{x^2-1}}\frac{d^n}{dx^n}[(x^2-1)^{n+0.5}]$	$(1-x^2)^{0.5}$ $\alpha=\beta=0.5$	−1	+1
			$\frac{d^n}{dx^n}[(x^2-1)^n]$	1 $\alpha=\beta=0$	−1	+1
			$C_{n+\alpha}^{n-k}\frac{(-x)^k}{k!}$ 0	$x^\alpha e^{-x}$	0	∞
			$C_n^{n-k}\frac{(-x)^k}{k!}$ 0	e^{-x}	0	∞
			$1)^n e^{x^2}\frac{d}{dx^n}(e^{-x^2})$	e^{-x^2}	∞	∞



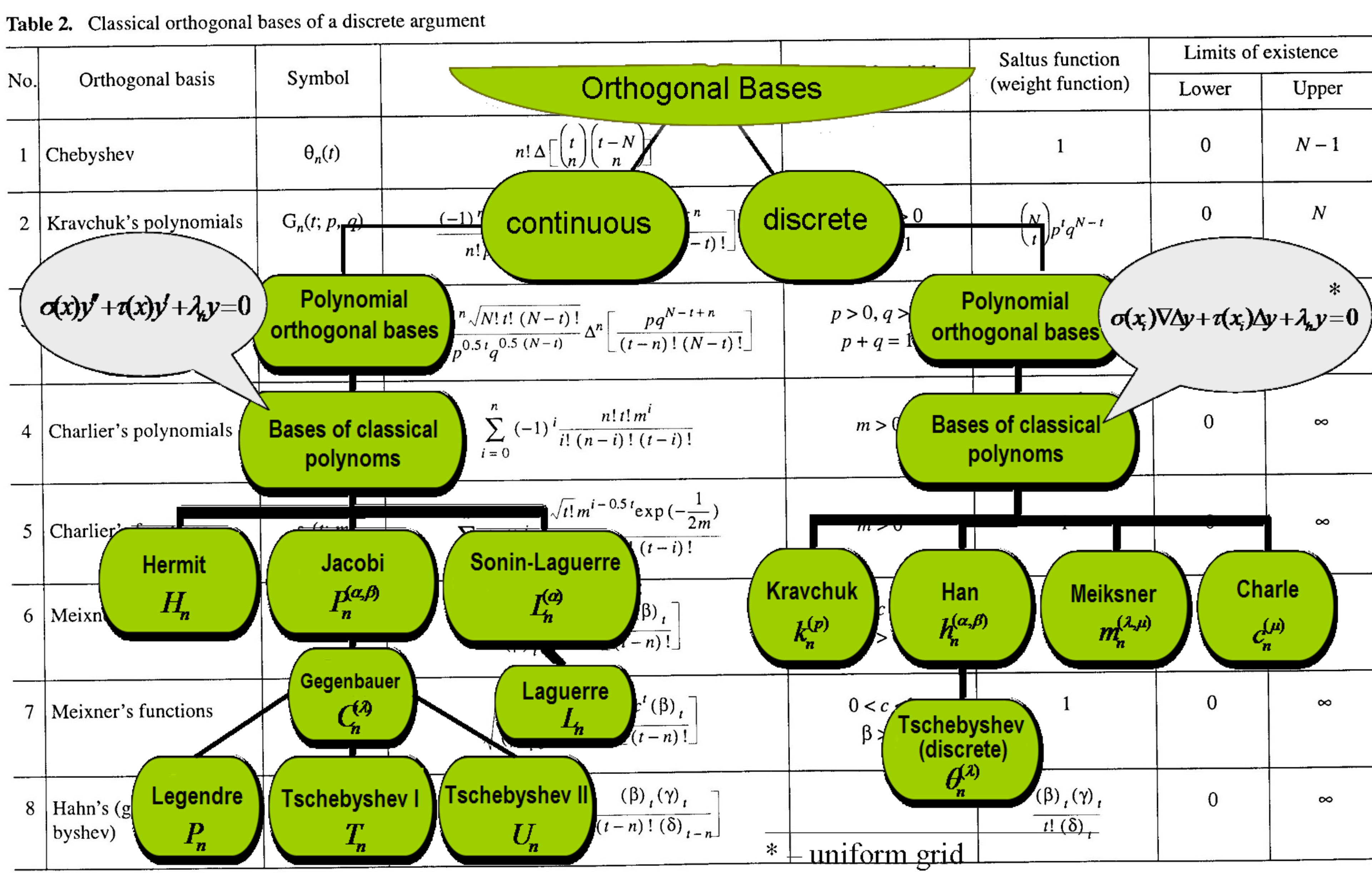
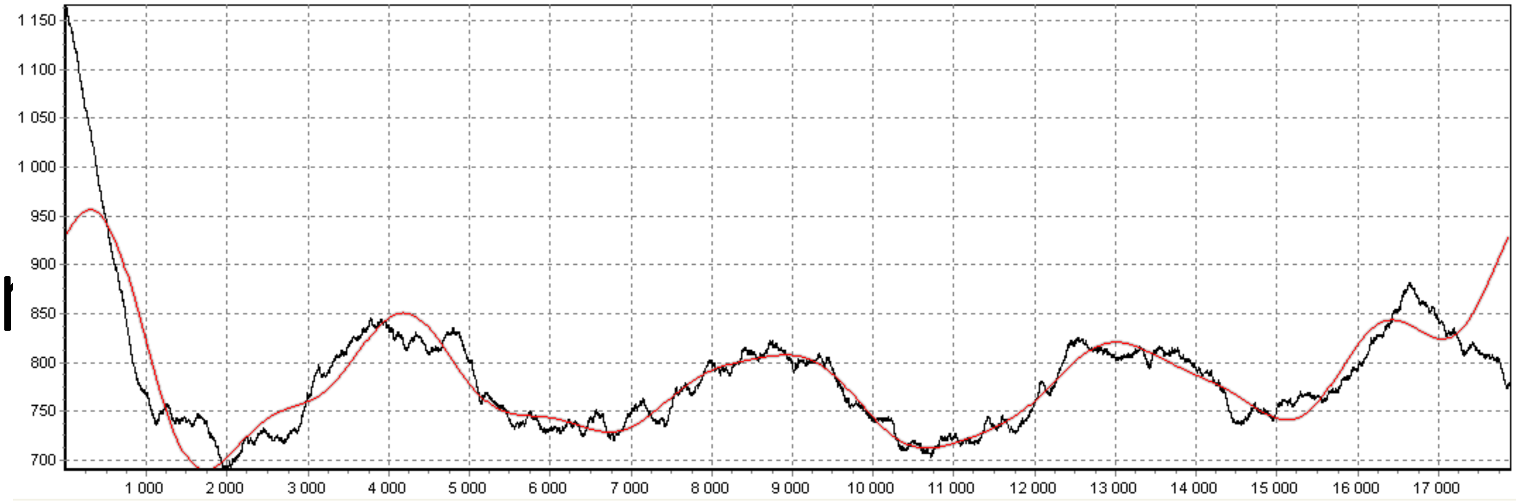


Table 2. Classical orthogonal bases of a discrete argument
No.
Orthogonal basis
Symbol
Saltus function (weight function)
Limits of existence
Lower
Upper
1 Chebyshev
2 Kravchuk's polynomials
4 Charlier's polynomials
7 Meixner's functions
Orthogonal Bases
continuous
discrete
Polynomial orthogonal bases
Polynomial orthogonal bases
$\sigma(x)y'' + \tau(x)y' + \lambda_n y = 0$
$\sigma(x_i)\nabla\Delta y + \tau(x_i)\Delta y + \lambda_n y = 0$ *
Bases of classical polynoms
Bases of classical polynoms
Hermit H_n
Jacobi $P_n^{(\alpha,\beta)}$
Sonin-Laguerre $L_n^{(\alpha)}$
Gegenbauer $C_n^{(\lambda)}$
Laguerre L_n
Legendre P_n
Tschebyshev I T_n
Tschebyshev II U_n
Kravchuk $k_n^{(p)}$
Han $h_n^{(\alpha,\beta)}$
Meiksner $m_n^{(\lambda,\mu)}$
Charle $c_n^{(\mu)}$
Tschebyshev (discrete) $\theta_n^{(\lambda)}$
* – uniform grid

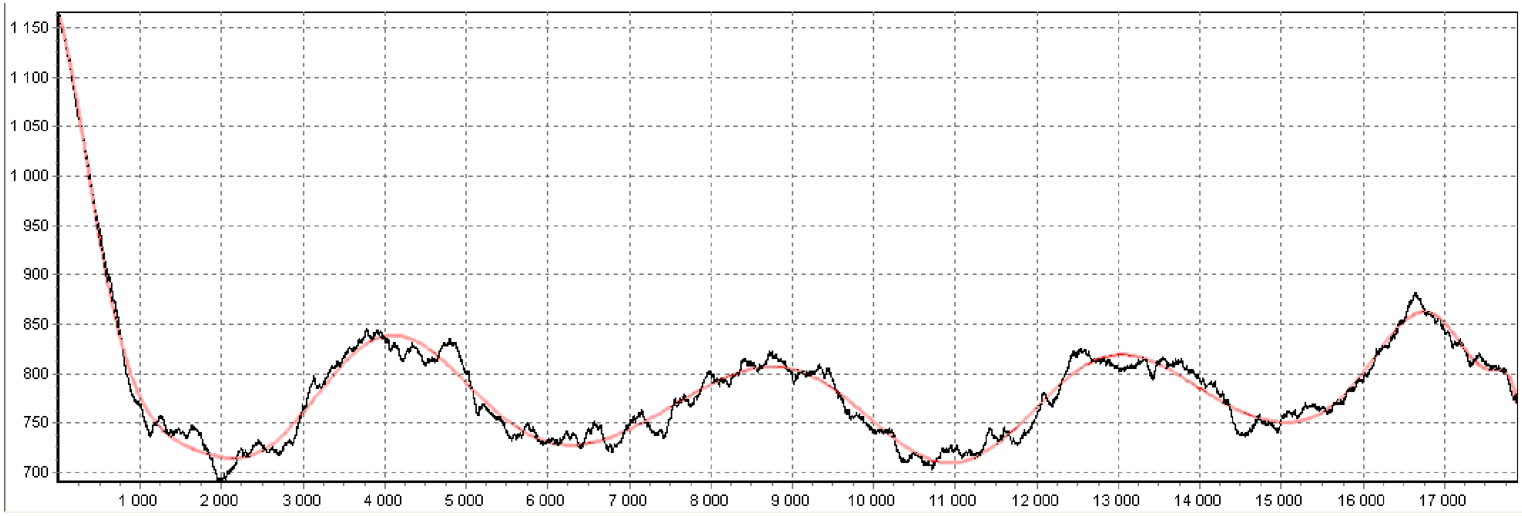
Table 3. Orthogonal bases of a continuous argument

No.	Orthogonal basis	Condition	Symbol	General expression	Weight $\rho(t)$	Limits of existence: Lower	Limits of existence: Upper
1	Shifted Jacobi polynomials	$\alpha > -1 \quad \beta > -1$	$Я_n^{\alpha\beta}(t, T)$	$\sqrt{\frac{(\alpha+\beta+2n+1)\,\Gamma(\alpha+\beta+n+1)\,\Gamma(\alpha+n+1)\,\Gamma(\beta+n+1)}{2^{\alpha+\beta}Tn!}}\frac{1}{T^n}\sum_{k=0}^{n}\frac{C_n^k(t-T)^k t^{n-k}}{\Gamma(\alpha+k+1)\,\Gamma(\beta+n-k+1)}$	$\frac{2^{\alpha+\beta}}{T^{\alpha+\beta}}(T-t)^{\alpha}t^{\beta}$	0	T
			$R_n^{\alpha\beta}(mT)$	$\sqrt{\frac{m(\alpha+\beta+2n+1)\,\Gamma(\alpha+\beta+n+1)\,\Gamma(\alpha+n+1)\,\Gamma(\beta+n+1)}{2^{\alpha+\beta}n!}}\sum_{k=0}^{n}\frac{(-1)^k C_n^k e^{-(0.5+k)mt}(1-e^{-mt})^{n-k}}{\Gamma(\alpha+k+1)\,\Gamma(\beta+n-k+1)}$	$2^{\alpha+\beta}e^{-\alpha mt}(1-e^{-mt})^{\beta}$	0	∞
2	Shifted Jacobi functions	$\alpha > -1 \quad \beta > -1$	$Я_n^{\alpha\beta}(t, T)$	$\sqrt{\frac{(\alpha+\beta+2n+1)\,\Gamma(\alpha+\beta+n+1)\,\Gamma(\alpha+n+1)\,\Gamma(\beta+n+1)}{n!\,T^{2n+\alpha+\beta+1}}}\sum_{k=0}^{n}\frac{(-1)^k C_n^k}{\Gamma(\alpha+k+1)}(T-t)^{\frac{\alpha}{2}+k}t^{\frac{\beta}{2}+n-k}$	1	0	T
			$r_n^{\alpha\beta}(mt)$	$\sqrt{\frac{m(\alpha+\beta+2n+1)\,\Gamma(\alpha+\beta+n+1)\,\Gamma(\beta+n+1)}{n!}}\sum_{k=0}^{n}\frac{(-1)^k C_n^k}{\Gamma(\alpha+k+1)\,\Gamma(\beta+n-k+1)}e^{-\frac{\alpha+1+2k}{2}mt}(1-e^{-mt})^{n-k}$	1	0	∞
3	Shifted Gegenbauer polynomials	$\alpha - \beta = \sigma - 0.5$	$C^{\sigma}(t, T)$	$\sqrt{\frac{(\sigma+n)\,\Gamma(2\sigma+n)}{2^{2\sigma-2}Tn!}}\,\Gamma(\sigma+n+0.5)\frac{1}{T^n}\sum_{k=0}^{n}\frac{C_n^k(t-T)^k t^{n-k}}{\Gamma(\sigma+k+0.5)\,\Gamma(\sigma+n-k+0.5)}$	$\frac{2^{2\sigma-1}}{T^{2\sigma-1}}(T-t)^{\sigma-0.5}t^{\sigma-0.5}$	0	T
			$C^{\sigma}(mt)$	$\sqrt{\frac{m(\sigma+n)\,\Gamma(2\sigma+n)}{2^{2\sigma-2}n!}}\,\Gamma(\sigma+n+0.5)\sum_{k=0}^{n}\frac{(-1)^k C_n^k e^{-(0.5+k)mt}}{\Gamma(\sigma+k+0.5)\,\Gamma(\sigma+n-k+0.5)}(1-e^{-mt})^{n-k}$	$2^{2\sigma-1}e^{-(\sigma-0.5)mt} \times (1-e^{-mt})^{\sigma-0.5}$	0	∞

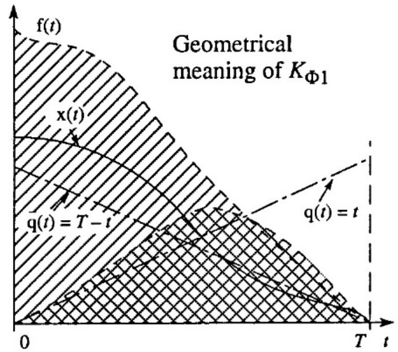


$$x(t) = \sum_{n=0} A_n \varphi_n(t)$$

$\varphi_n(t)$ - functional orthogonal basis



<u>Form coefficient</u>

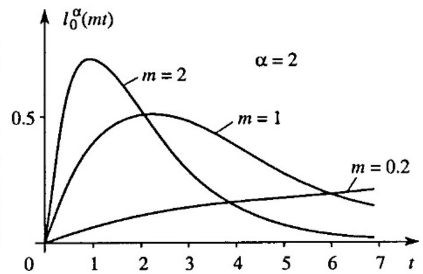


$$K_{\Phi q} = \frac{\bar{J}_q}{J_q} = \frac{\int_0^T x(t)\,\bar{q}(t)\,dt}{\int_0^T x(t)\,q(t)\,dt}; \qquad K_{\Phi q} = \frac{\sum_{t=0}^{N} x(t)\,\bar{q}(t)}{\sum_{t=0}^{N} x(t)\,q(t)};$$

t – continuous argument, t – discrete argument.

x(t)' – the signal

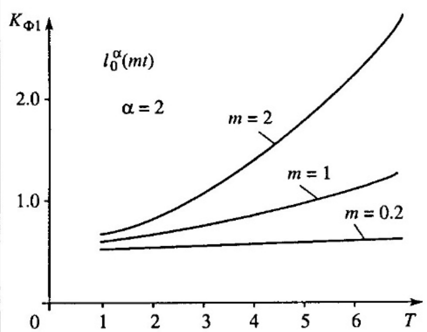
q(t)' – known function



For $q(t) = t^n$, $\bar{q}(t) = (T-t)^n$ For $q(t) = e^{-at}$, $\bar{q}(t) = e^{-a(T-t)}$

$$K_{\Phi n} = \frac{\int_0^T x(t)\,(T-t)^n dt}{\int_0^T x(t)\,t^n dt}, \qquad K_{\Phi e} = \frac{\int_0^T x(t)\,e^{-a(T-t)} dt}{\int_0^T x(t)\,e^{-at} dt},$$

power form coefficient exponential form coefficient

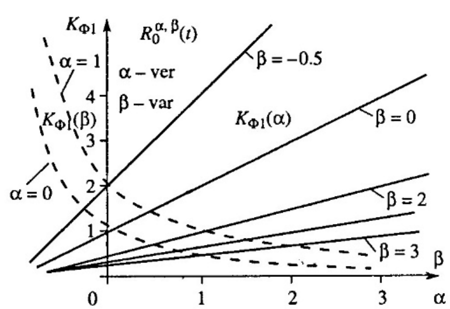


$$K_{\Phi 1} = \frac{\int_0^T x(t)\,(T-t)\,dt}{\int_0^T x(t)\,t\,dt} = \frac{T\int_0^T x(t)\,dt - \int_0^T x(t)\,t\,dt}{\int_0^T x(t)\,t\,dt} = T\frac{J_0}{J_1} - 1.$$

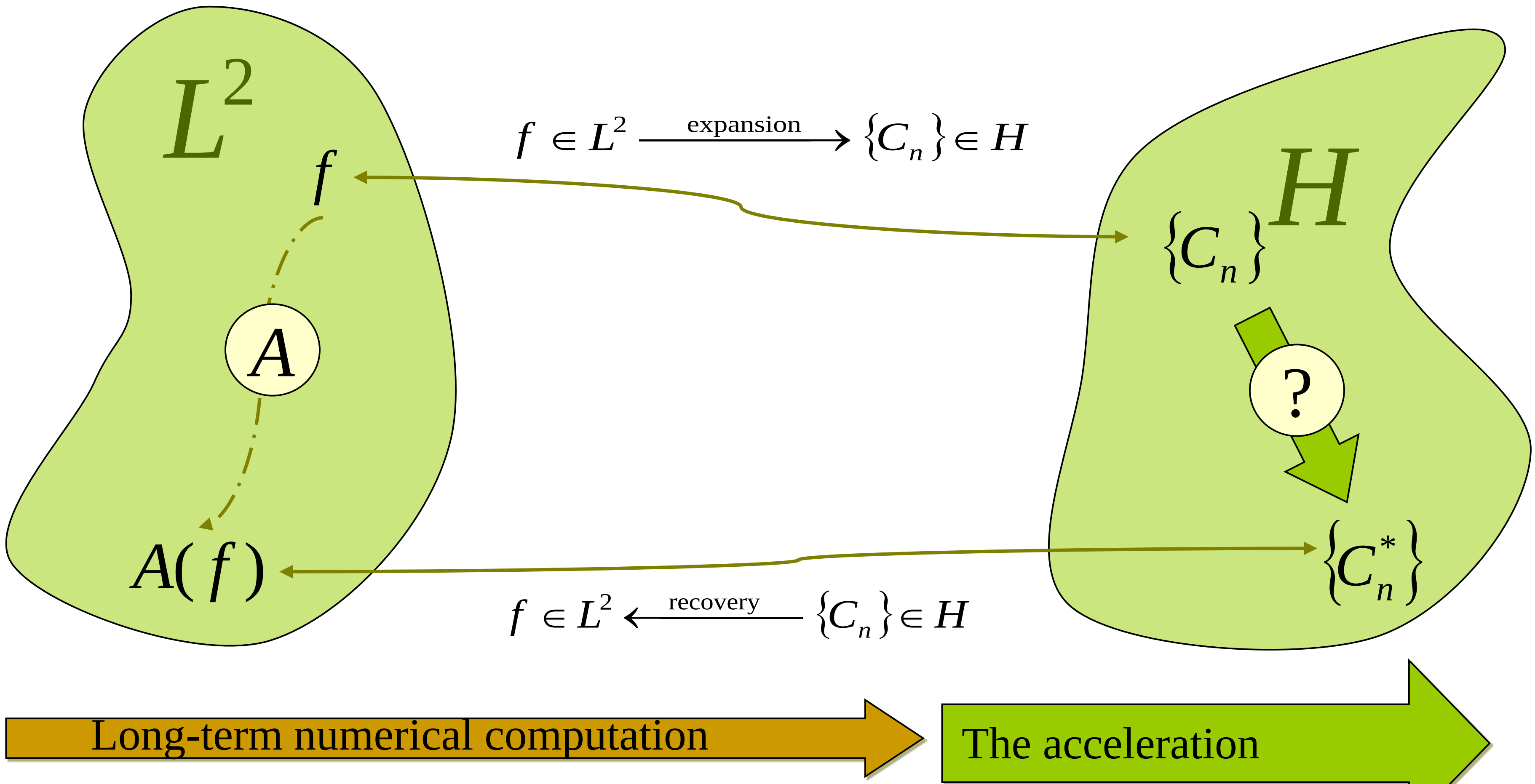
If $K_{\Phi 1} > 1$, then x(t) – decays on [0, T];

If $K_{\Phi 1} < 1$, then x(t) – increases on [0, T];

If $K_{\Phi 1} \approx |1|$, then x(t) – is periodical (nondecreasing).



Transformations in the space of coefficients



$$f(x) \xrightarrow{\text{Digital transformations } A()} A(f(x))$$

$$\{C_n\} \xrightarrow{\text{How to calculate?}} \{C_n^*\}$$

$$\hat{L} = \frac{d^k}{dx^k} + a_1 \frac{d^{k-1}}{dx^{k-1}} + \ldots + a_{k-1} \frac{d}{dx} + a_k$$

$$\hat{L}y = f$$

$$\hat{g}y \Big|_s = f_0$$

$$\hat{g} = \frac{d^{k-1}}{dx^{k-1}} + b_1 \frac{d^{k-2}}{dx^{k-2}} + \ldots + b_{k-2} \frac{d}{dx} + b_{k-1}.$$

$$y = \sum_{i=0}^{N} p_i T_i, \qquad f = \sum_{i=0}^{N} h_i T_i \quad \text{и} \quad \sum_{i=0}^{N} a_i \hat{g} T_i \Big|_s = f_0$$

Derivative approximation

$$y'_N(t) = \sum_{i=0}^{N} d_i^{(1)} T_i(t),$$

$$\mathbf{d}^{(1)} = \mathbf{D_N}\mathbf{p},$$

$$\mathbf{d}^{(\mathbf{k})} = \mathbf{D}_{\mathbf{N-k+1}} \cdot \ldots \cdot \mathbf{D_N}\mathbf{p}.$$

$$\hat{L} \qquad \left\{ d_{ij}^{(\hat{L})} \right\} = \left\{ d_{ij}^{(k)} + a_1 d_{ij}^{(k-1)} + \ldots + a_{k-1} d_{ij}^{(1)} + a_k \right\}$$

Derivative approximation in Chebyshev basis

$$\mathbf{D_N} = N-1 \left\{ \overbrace{\begin{pmatrix} 0 & \begin{array}{|cccccc} \sqrt{2} & 0 & 3\sqrt{2} & 0 & 5\sqrt{2} & \ldots. \\ 0 & 4 & 0 & 8 & 0 & \ldots. \\ 0 & 0 & 6 & 0 & 10 & \ldots. \\ & & \ddots & & & \\ & & & \ddots & & \\ 0 & 0 & \ldots. & 0 & 0 & 2N \end{array} \end{pmatrix}}^{N} \right.$$

$$b_0 = \sqrt{2}\,p_1 + 3\sqrt{2}\,p_3 + 5\sqrt{2}\,p_5 + ... + N\sqrt{2}\,p_N$$

$$b_1 = 4\,p_2 + 8_4 + 12\,p_6 + ... + 2(N-1)\,p_{N-1}$$

$$b_2 = 6\,p_3 + 10\,p_5 + 14\,p_7 + ... + 2Np_N$$

....

$$b_{N-1} = 2Np_N$$

Derivative approximation in Legendre basis

$$\mathbf{D_N} = N-1\left\{ \overbrace{\begin{pmatrix} & \sqrt{3} & 0 & \sqrt{7} & 0 & \sqrt{11} & .... \\ & 0 & \sqrt{3}\sqrt{5} & 0 & \sqrt{3}\sqrt{9} & 0 & .... \\ 0 & 0 & 0 & \sqrt{5}\sqrt{7} & 0 & \sqrt{5}\sqrt{11} & .... \\ & & & \ddots & & & \\ & & & & \ddots & & \\ & 0 & 0 & .... & 0 & 0 & \sqrt{2N-1}\sqrt{2N+1} \end{pmatrix}}^{N} \right.$$

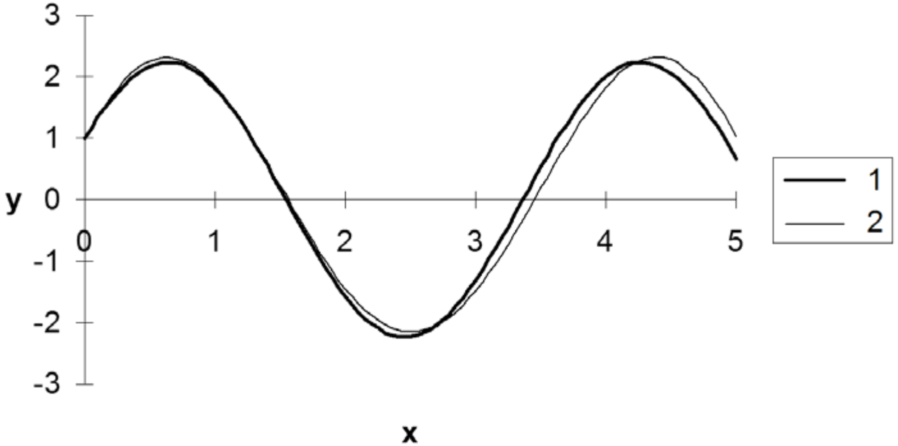
Example

$$u(x) = \sum_{k=0}^{N=8,16} A_k \varphi_k(x)$$

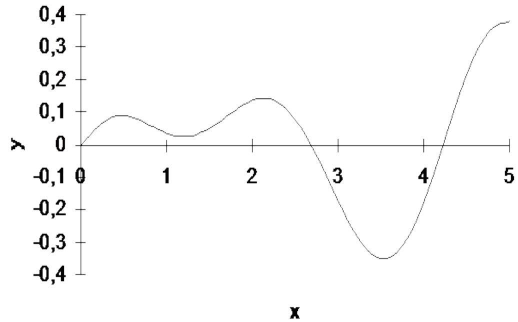
$$u'' + 3u = 0,$$
$$u(0) = 1,$$
$$u'(5) = 2\sqrt{3}\cos(5\sqrt{3}) - \sqrt{3}\sin(5\sqrt{3}).$$

$$u(x) = \cos(\sqrt{3}x) + \sin(\sqrt{3}x).$$

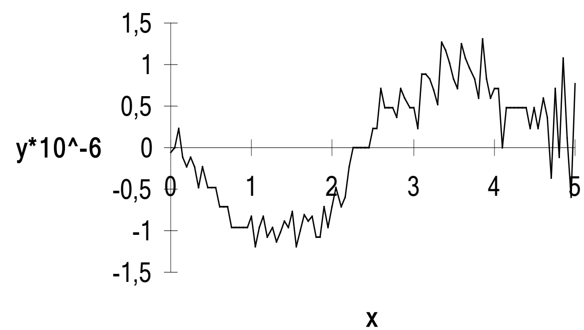
N=8



N=8



N=16



$$f(x) = \int y(x)\,dx$$

$$\mathbf{b} = \mathbf{I}_{\mathbf{n}}\mathbf{h}$$

$$\mathbf{I_N} = N\left\{\overbrace{\begin{pmatrix} \frac{1}{\sqrt{2}} & 0 & -\frac{1}{2} & 0 & 0 & \dots. \\ 0 & \frac{1}{4} & 0 & -\frac{1}{4} & 0 & \dots. \\ 0 & 0 & \frac{1}{6} & 0 & -\frac{1}{6} & \dots. \\ & & \ddots & & & \\ & & & \ddots & & \\ 0 & 0 & \dots. & 0 & 0 & \frac{2}{2(N+1)} \end{pmatrix}}^{N}\right.$$

$$\mathbf{b} = \begin{pmatrix} \beta_1 \\ \beta_2 \\ \dots \\ \beta_N \end{pmatrix} \qquad \mathbf{h} = \begin{pmatrix} \eta_1 \\ \eta_2 \\ \dots \\ \eta_N \end{pmatrix}$$

$$\beta_1 = \frac{\eta_0}{\sqrt{2}} - \frac{\eta_2}{2},$$

$$\beta_2 = \frac{\eta_1}{4} - \frac{\eta_3}{4},$$

$$\beta_3 = \frac{\eta_2}{6} - \frac{\eta_4}{6},$$

$$\dots\dots\dots\dots\dots$$

$$b_{N+1} = \frac{1}{2N+1}\eta_N$$

Wiener-Hopf equation

$$u(x) - \int_0^{\infty} R(x-s)\,u(s)\,ds = f(x)$$

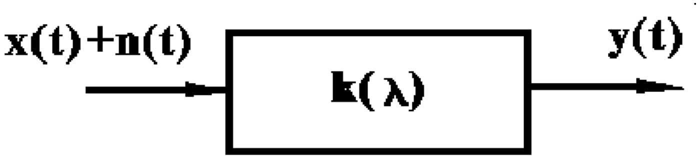
$R(x) = R_1(x) + \delta(x)$,

$f_1(x) = -f(x)$

$$\int_{-\infty}^{+\infty} \varphi(s)\,\delta(x-s)\,ds = \varphi(x)$$

$$\int_0^{\infty} R_1(x-s)\,u(s)\,ds = f_1(x)$$

$$R_{xy}(\tau) = \int_0^\infty R_{xx}(\tau - \lambda)k(\lambda)d\lambda,$$



$$y(t) = \int_0^t x(t-\tau)k(\tau)d\tau.$$

$$R_{xy}(\tau) = \int_0^\infty R_{xx}(\tau)k(\lambda)d\lambda = -\int_\tau^\infty R_{xx}(\tau)k(\tau - \lambda)d\lambda =$$

$$= \int_{-\infty}^0 R_{xx}(\tau)k(\tau - \lambda)d\lambda + \int_0^\tau R_{xx}(\lambda)k(\tau - \lambda)d\lambda.$$

$$\int_{-\infty}^0 R_{xx}(\lambda)k(\tau - \lambda)d\lambda = \int_\infty^0 R_{xx}(-\lambda)k(\tau + \lambda)d(-\lambda) =$$

$$= \int_0^\infty R_{xx}(-\lambda)k(\tau + \lambda)d\lambda = \int_0^\infty R_{xx}(\lambda)k(\tau + \lambda)d\lambda.$$

$$R_{xx}(\tau) = \sum_{i=0}^N C_i l_i(m\tau),$$

$$R_{xy}(\tau) = \sum_{i=0}^N D_i l_i(m\tau).$$

$$k(\lambda) = \sum_{i=0}^N E_i l_i(m\tau)$$

l_i - i^{th} Laguerre function with parameter $m>0$

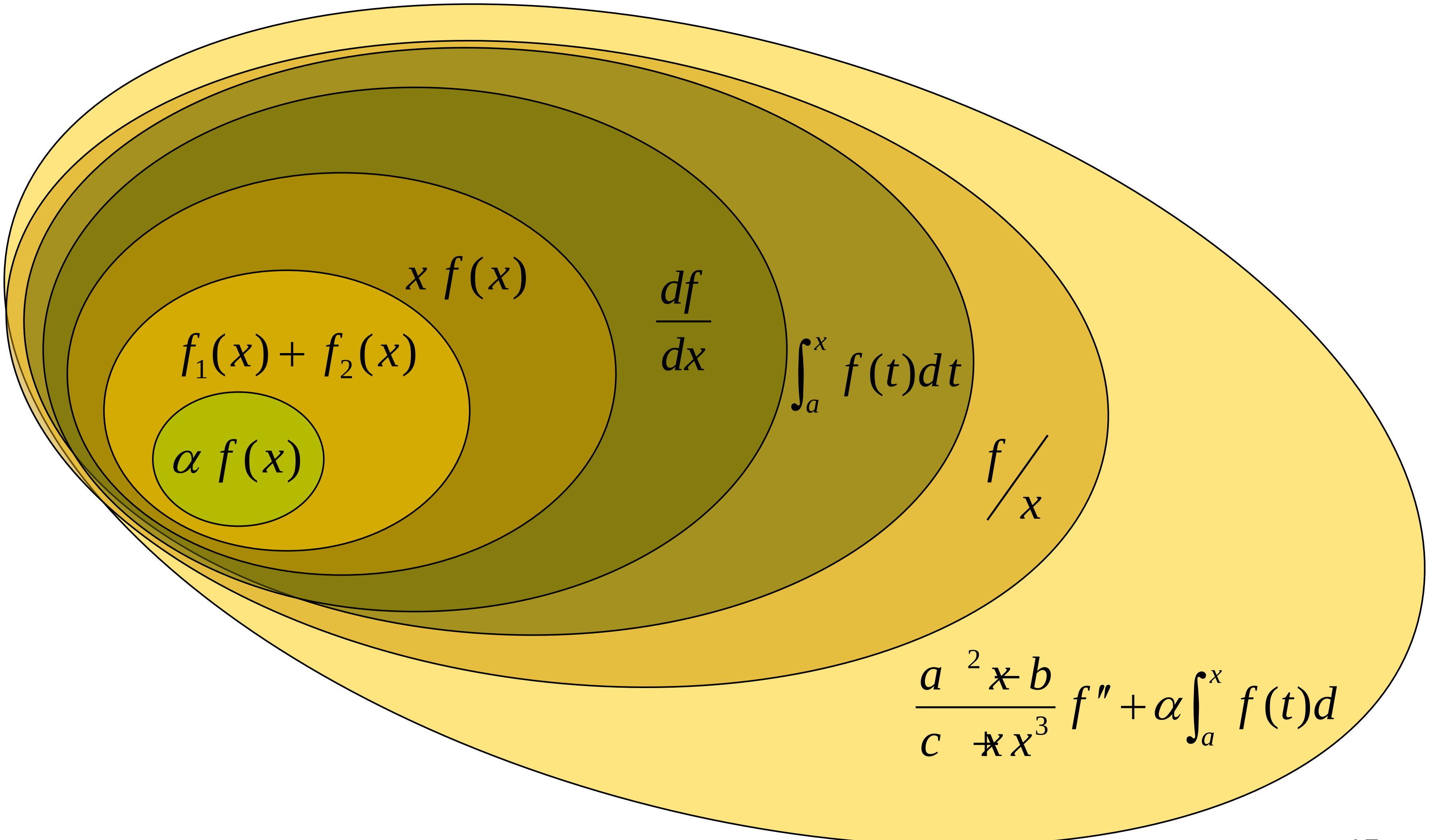
$$\int_0^\infty R_{xx}(\lambda)k(\tau + \lambda)d\lambda = \sum_{p=0}^N C_p \sum_{j=0}^N E_j \int_0^\infty l_p(m\lambda) l_j(m\tau + m\lambda)d\lambda.$$

$$l_n(m(x+y)) = \frac{1}{\sqrt{m}} \sum_{j=0}^n l_j(mx)\left\{l_{n-j}(my) - l_{n-j-1}(my)\right\}$$

$$\sqrt{m}D_i = C_0 E_i + \sum_{j=0}^N E_j (C_{|i-j|} - C_{|i-j|-1}),$$

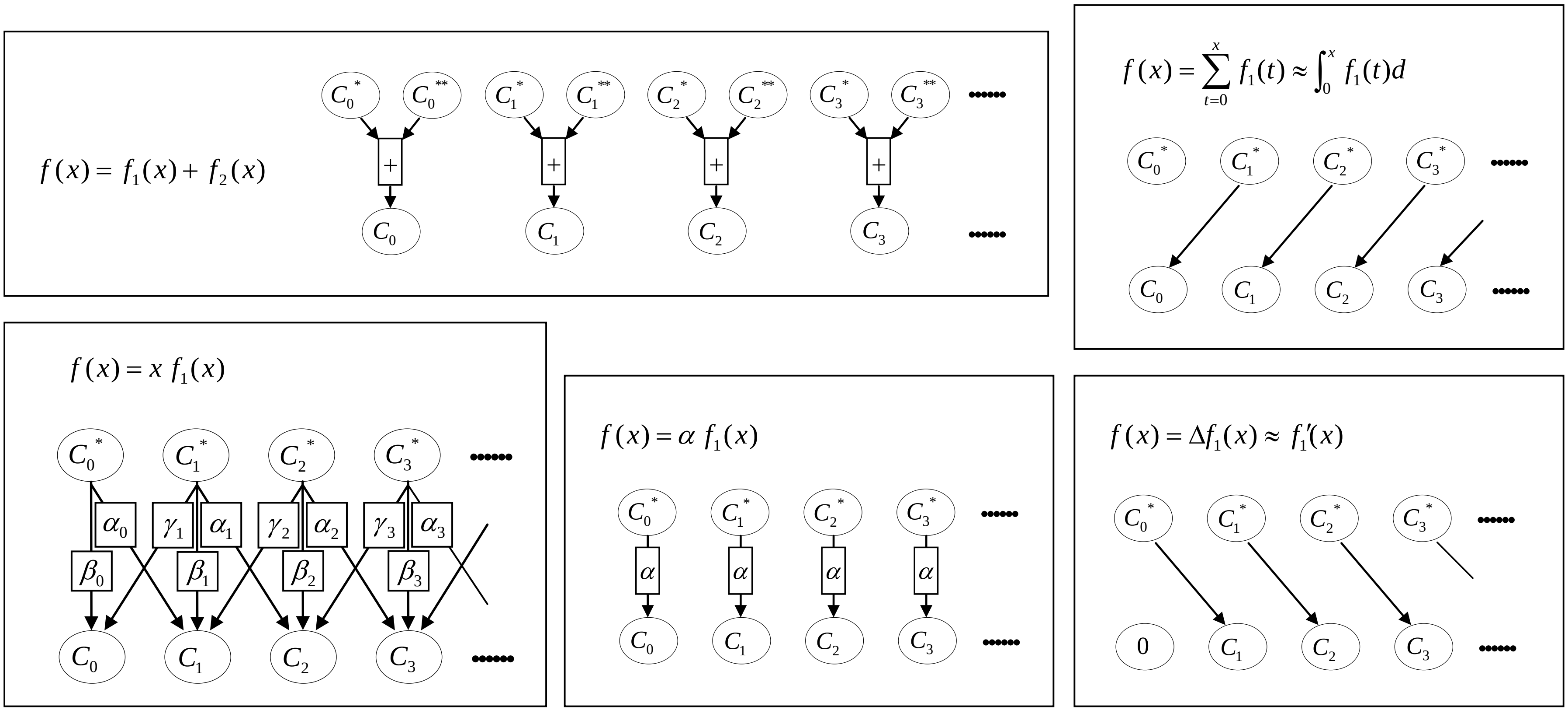
$$C_i \equiv 0 \text{ for } \forall i < 0,$$

Operators, realized as a quick ‘autospectral' algorithms



Recurrent calculations of coefficients. The method of fast series transformation *O(N)*

Analytical transformations and the corresponding changes in the spectral coefficients using orthogonal polynomials of Kravchuk



Parallel computing for the ultrafast transformation of spectral series *O(ln N)*

Functional calculation

$$f = \int (\alpha f_1' + x^2 f_2) dx$$

$$f(x) \approx \sum_{t=0}^{x} \left(\alpha \Delta f_1(t) + x^2 f_2(t)\right)$$

By means of expansion coefficients

Spactra of f_1 and f_2:

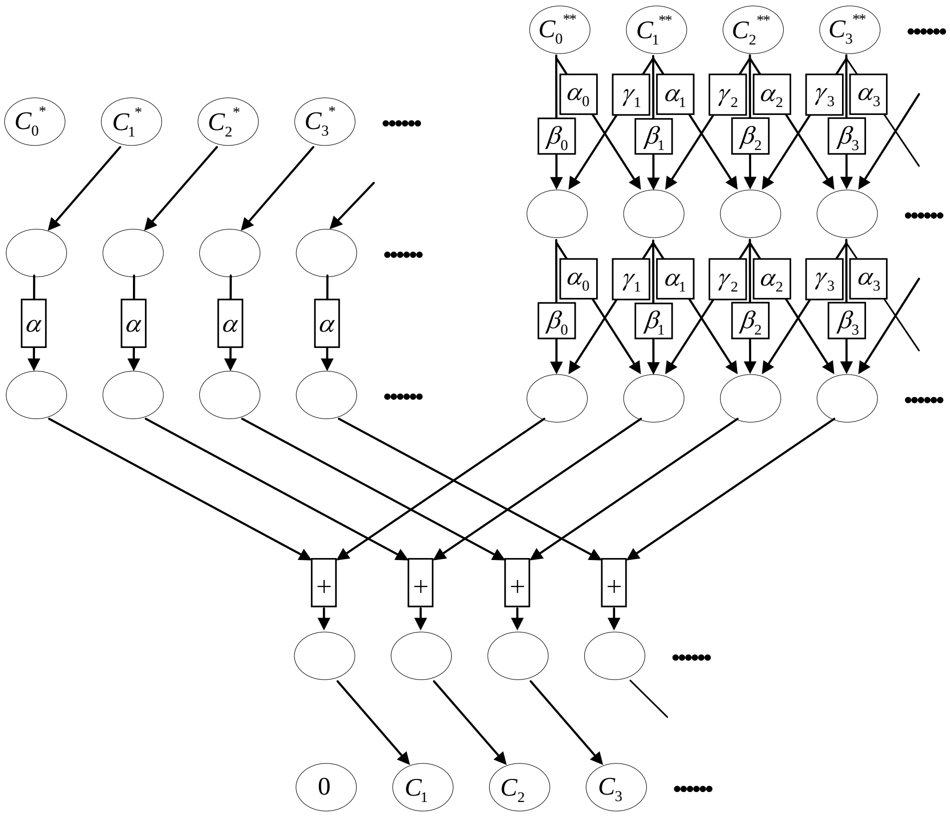
$\{C_0^*, \quad C_1^*, \quad C_2^*, \quad ...\}$

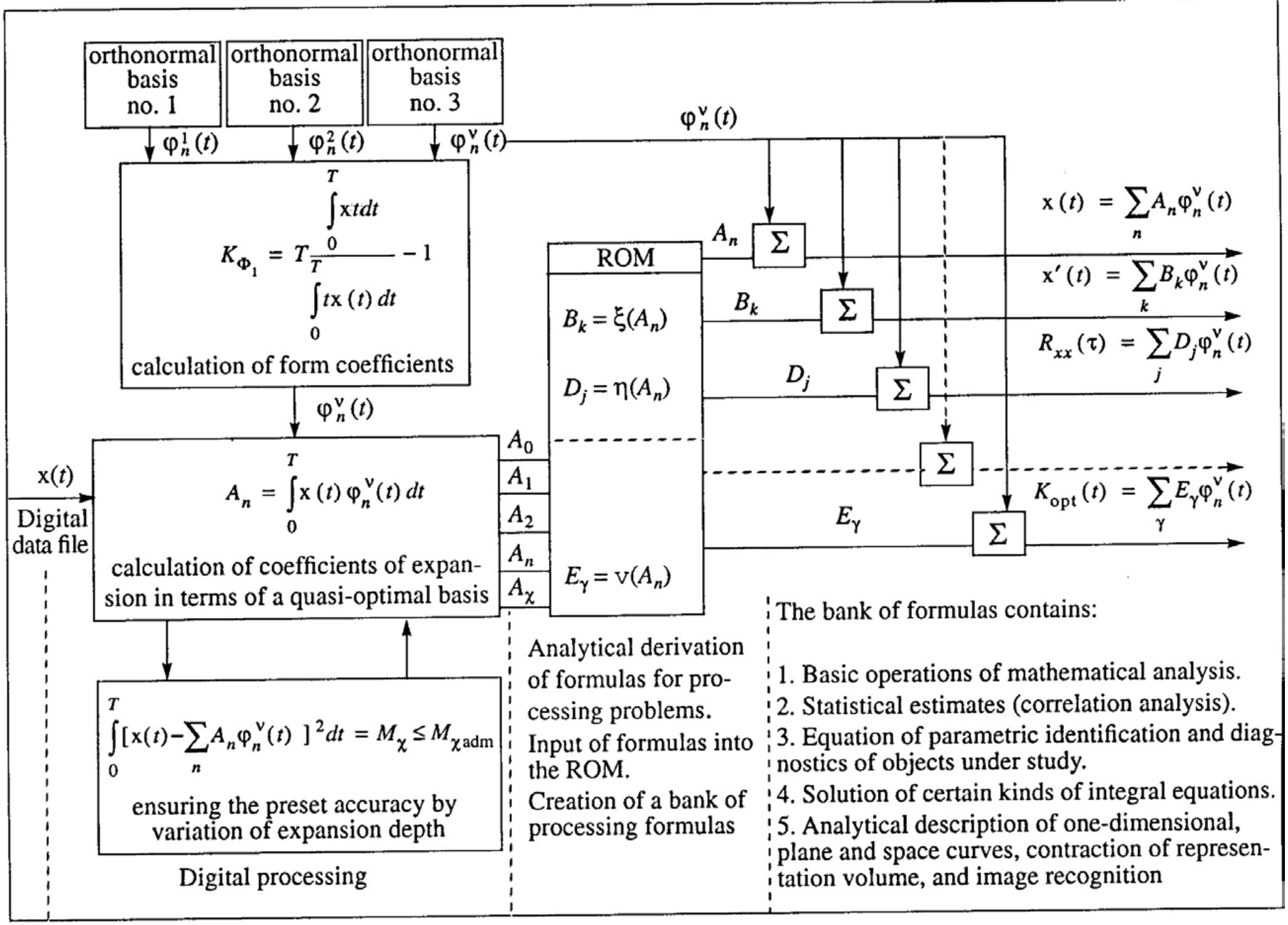
and

$\{C_0^{**}, C_1^{**}, C_2^{**}, ...\}$.

Result – spectrum of *f(x)*:

$\{C_0, \quad C_1, \quad C_2, \quad ...\}$





$$x(t) \approx \sum_{n=0}^{N=N_{min}} A_n \varphi_n(t)$$

IMAGE ANALYSIS AND PATTERN RECOGNITION

Parametric representation of space curves

$$\left.\begin{aligned} x &= \mathrm{x}(t) \\ y &= \mathrm{y}(t) \\ z &= \mathrm{z}(t) \end{aligned}\right\}$$

The vector form

$$\mathbf{F} = \mathbf{i}\mathrm{x}(t) + \mathbf{j}\mathrm{y}(t) + \mathbf{k}\mathrm{z}(t)$$

$$\mathrm{x}(t) = \sum_{n=0}^{N} A_n \varphi_n(t);$$

$$\mathrm{y}(t) = \sum_{k=0}^{K} B_k \psi_k(t);$$

$$\mathrm{z}(t) = \sum_{i=0}^{J} C_i \eta_i(t);$$

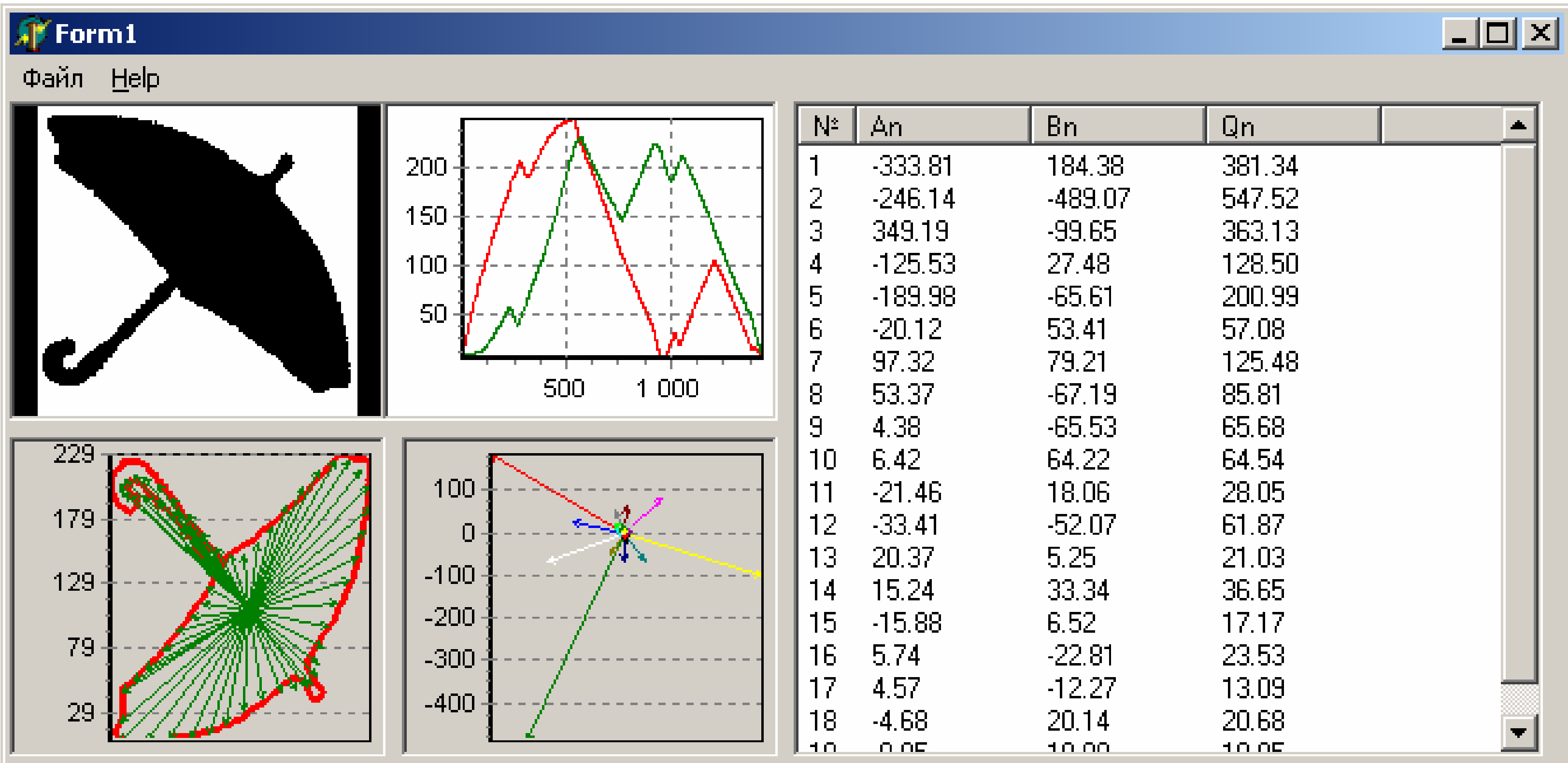
The root-mean-square error of the approximation:

$$\theta_n = \frac{\int_a^b \left[\mathrm{x}(t) - \sum_{n=0}^{N} A_n \varphi_n(t)\right]^2 dt}{\int_a^b \mathrm{x}^2(t)\,dt} = 1 - \frac{\sum_{n=0}^{N} A_n^2}{\int_a^b \mathrm{x}^2(t)\,dt}.$$

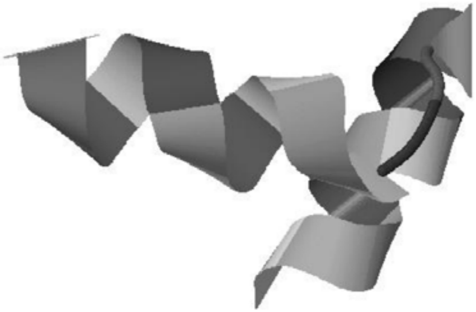
or accuracy:

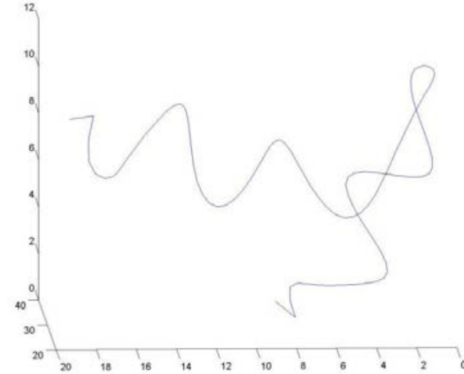
$$\gamma_n = 1 - \theta_n = \frac{\sum_{n=0}^{N} A_n^2}{\int_a^b \mathrm{x}^2(t)\,dt} = \frac{\sum_{n=0}^{N} A_n^2}{B_x}.$$

Analytical description of contours and selection of analytical features



Software for OCR

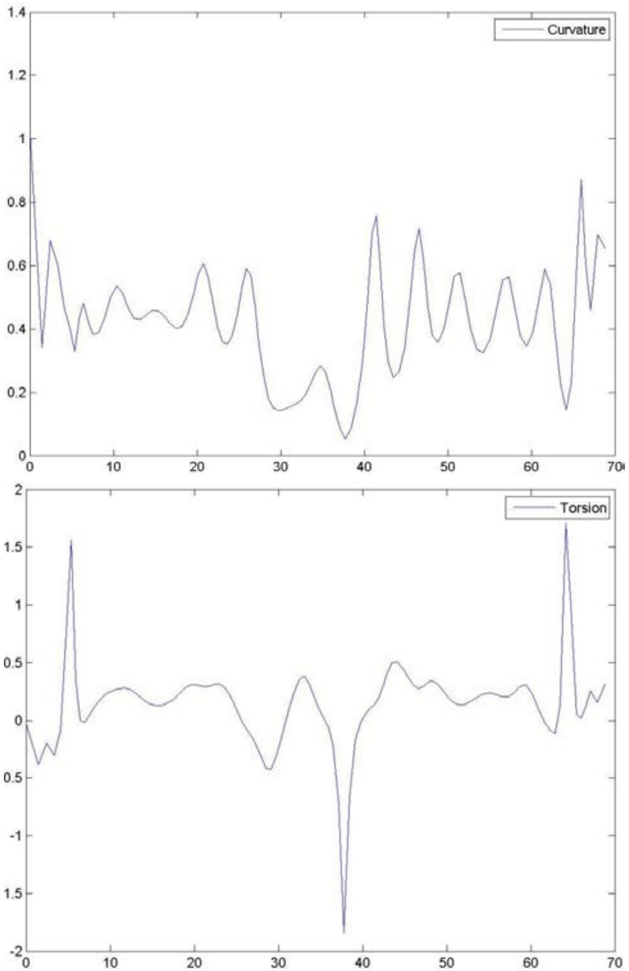




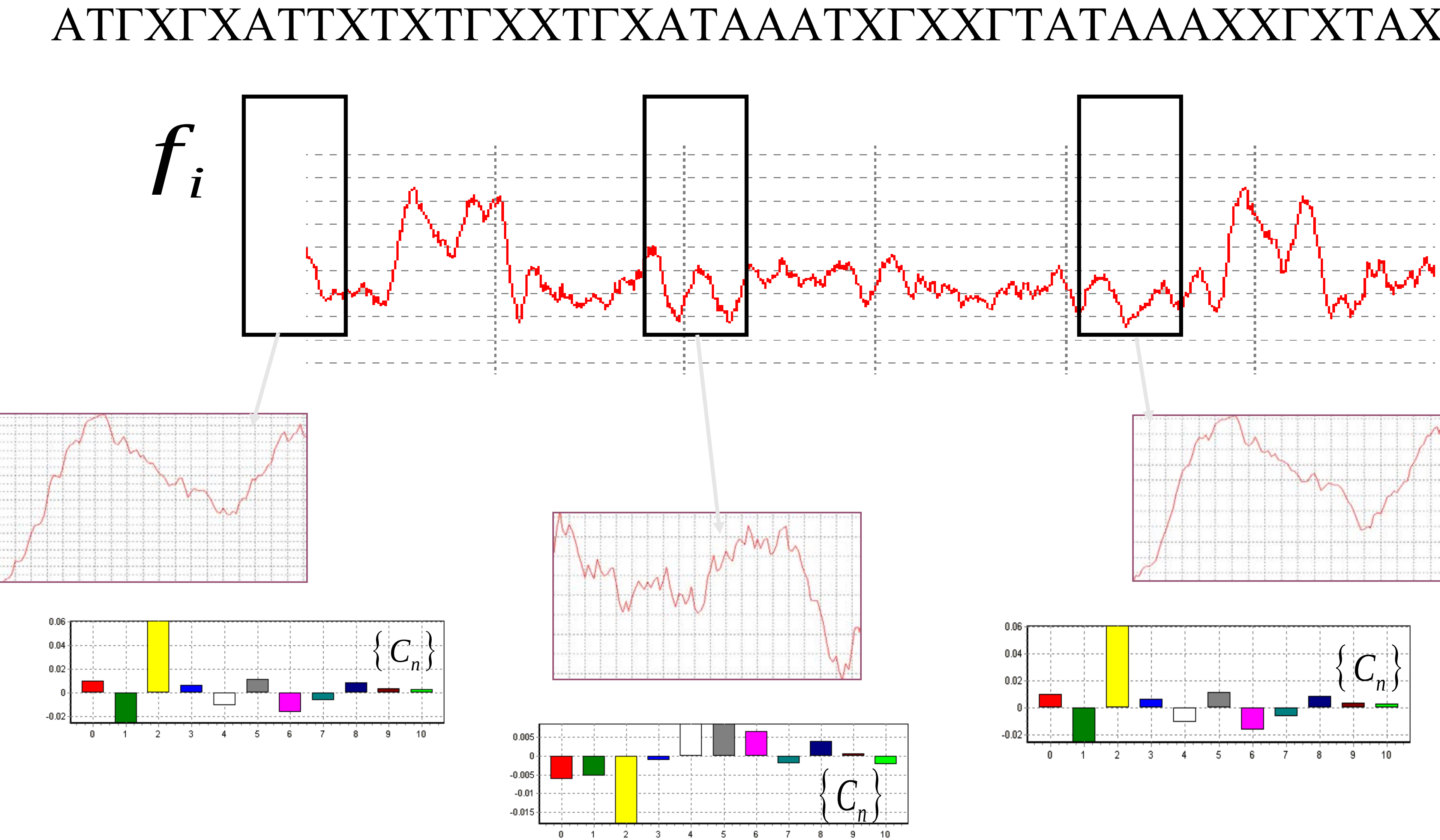
$$\begin{cases} x = x(t), \\ y = y(t), \\ z = z(t) \end{cases}$$

$$\begin{cases} x(t) = \sum_{i=0}^{N} A_i \varphi_i(t) \\ y(t) = \sum_{i=0}^{N} B_i \varphi_i(t) \\ z(t) = \sum_{i=0}^{N} C_i \varphi_i(t) \end{cases}$$

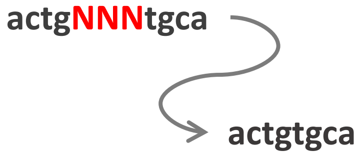
$$\begin{cases} C(s) = \sqrt{\ddot{x}^2 + \ddot{y}^2 + \ddot{z}^2}, \\ T(s) = \dfrac{\begin{vmatrix} \dot{x} & \dot{y} & \dot{z} \\ \ddot{x} & \ddot{y} & \ddot{z} \\ \dddot{x} & \dddot{y} & \dddot{z} \end{vmatrix}}{\ddot{x}^2 + \ddot{y}^2 + \ddot{z}^2} \end{cases}$$



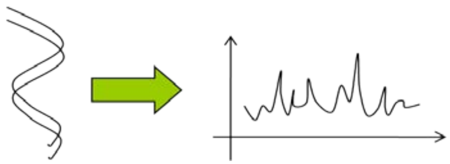
Repeats search in genomes



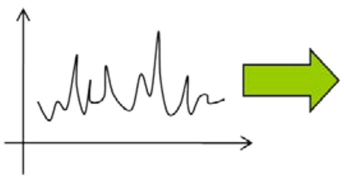
General scheme of the algorithm



Preliminary DNA processing последовательностей



Preparation of DNA profiles : GC%, GA%

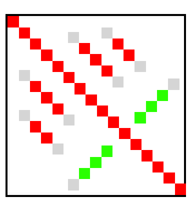


$$\{C_n\}$$

Converting the DNA profiles in the spectral representation

$$\theta(\{C_n\},\{C'_n\}) < \varepsilon$$

Comparison of the spectra of DNA fragments profiles

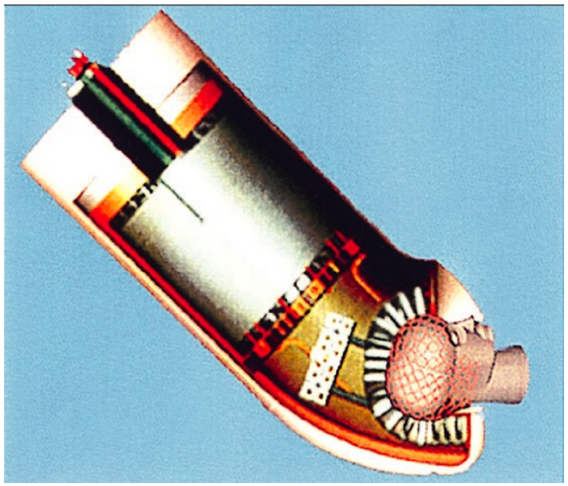


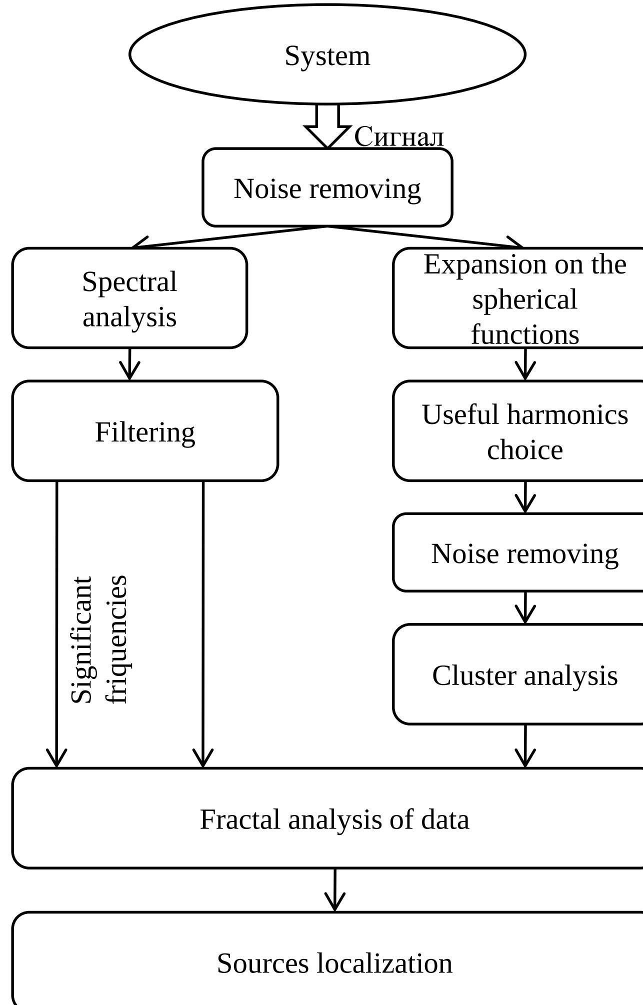
Showing results in the matrix of spectral similarity and analysis

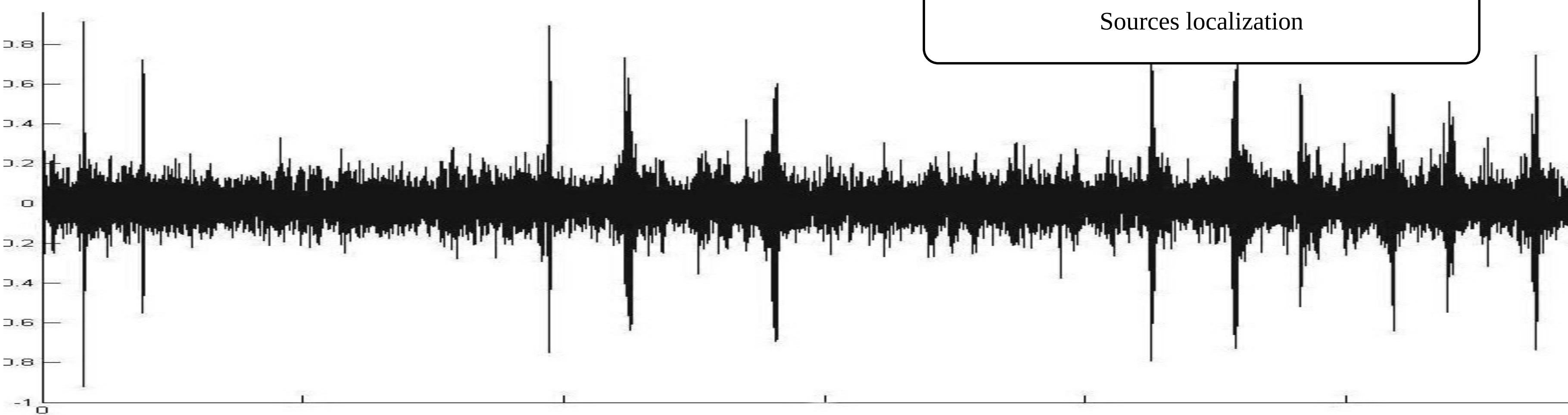
Magnetic encephalography

Measuring complex Magnes 2500 WH

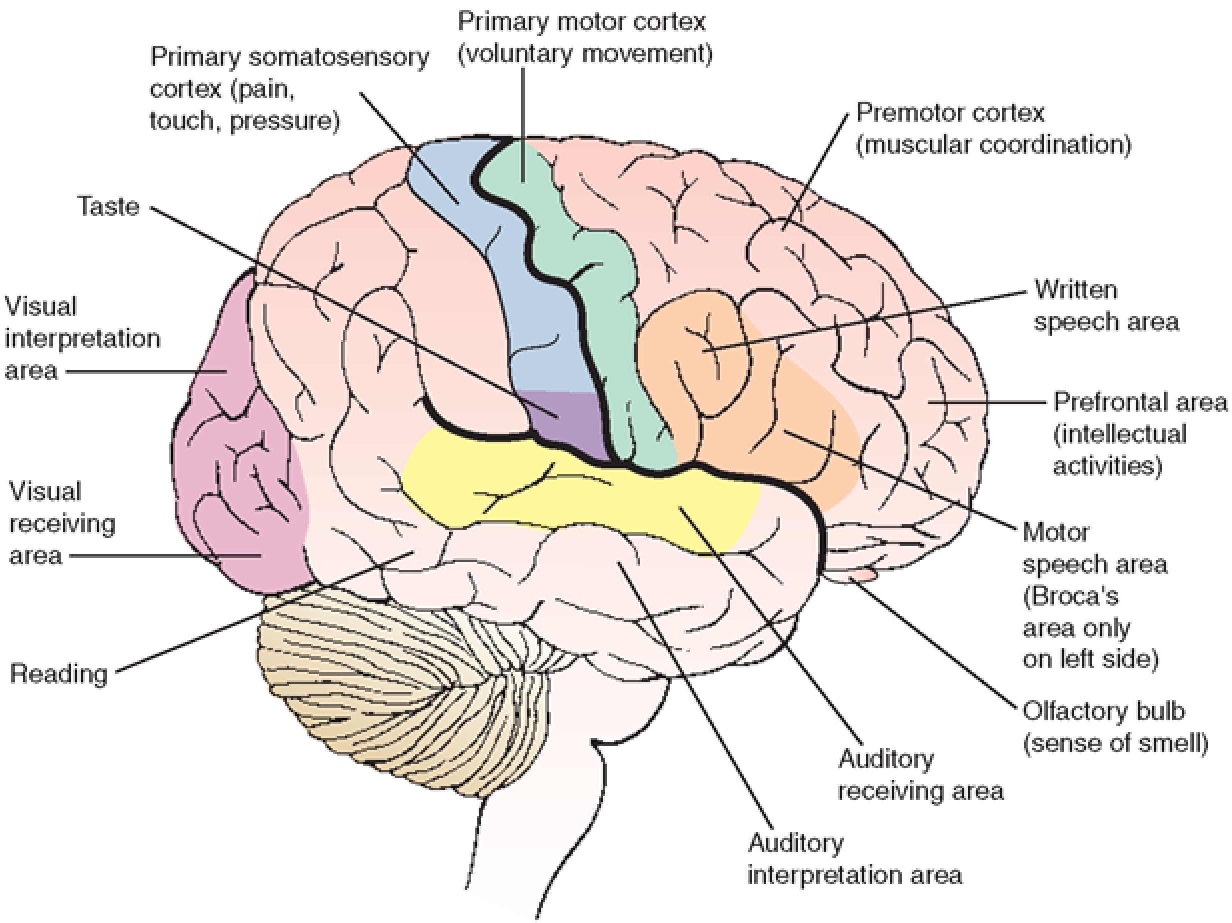
(New York, USA)



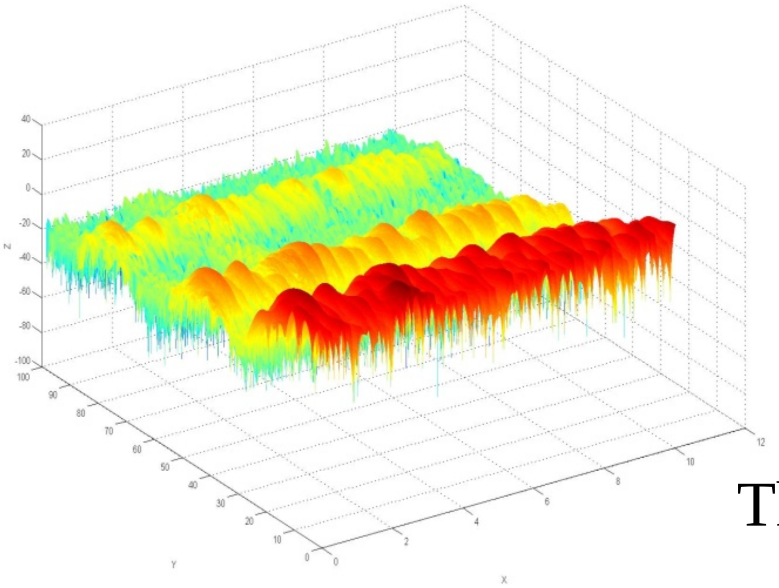


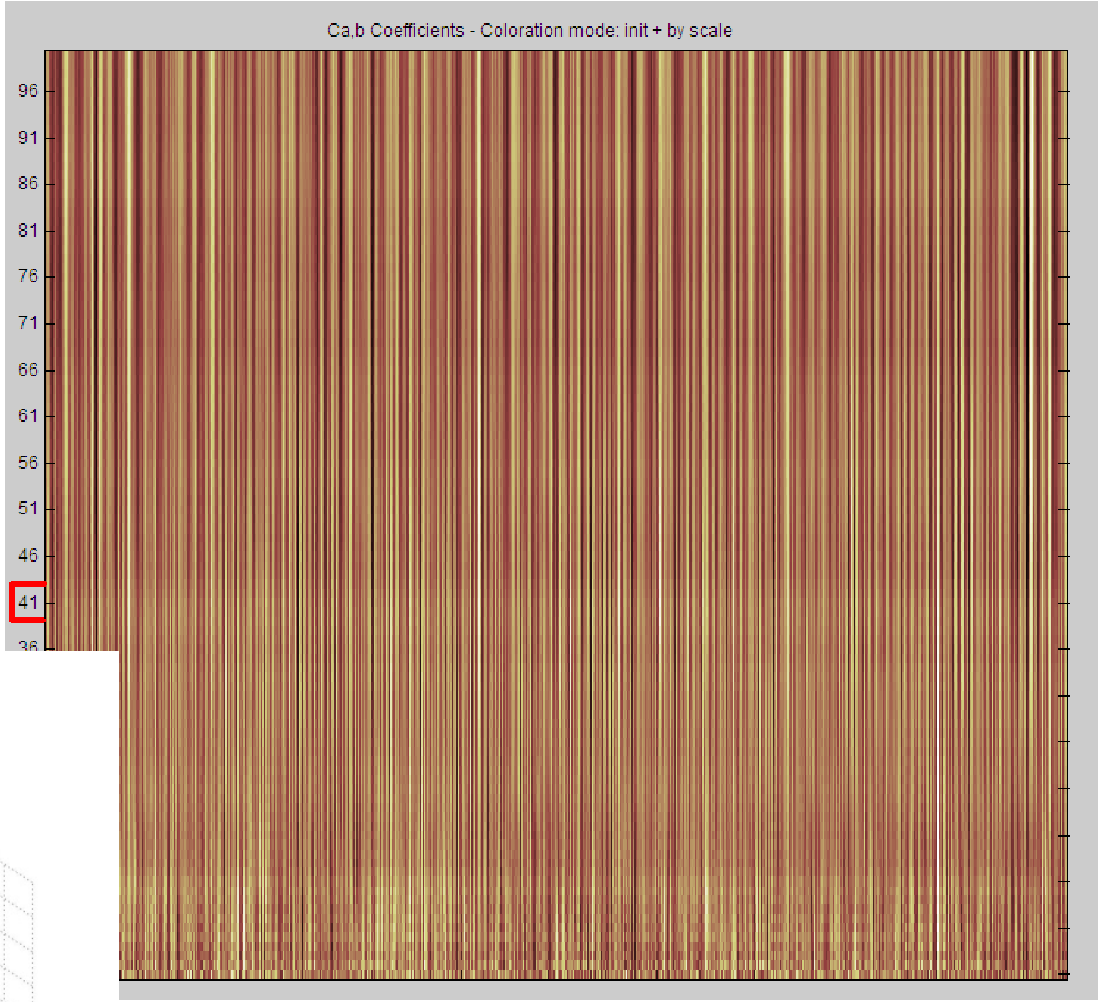


The brain functional areas mapping



Audio stimulation

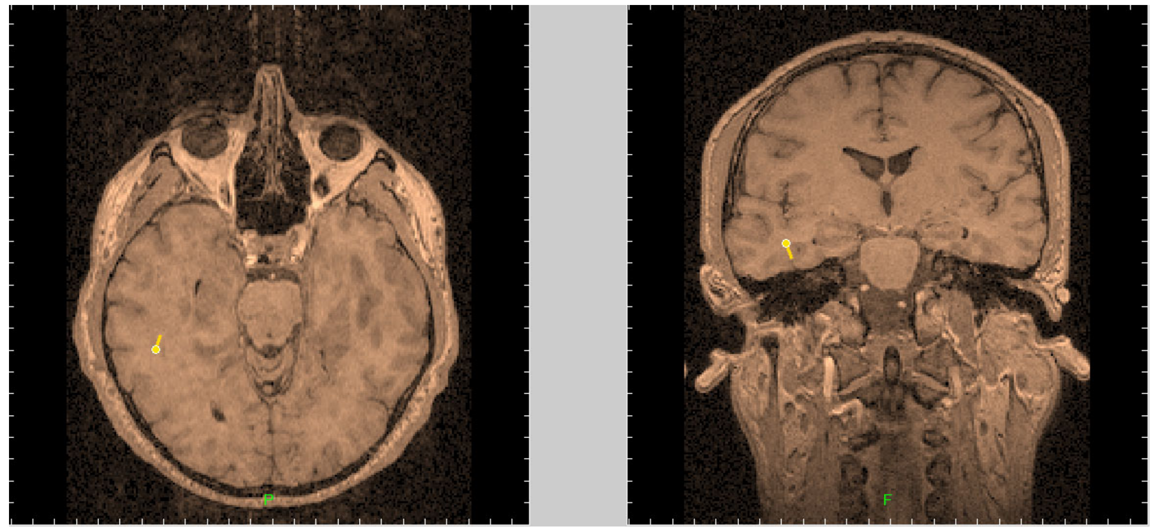




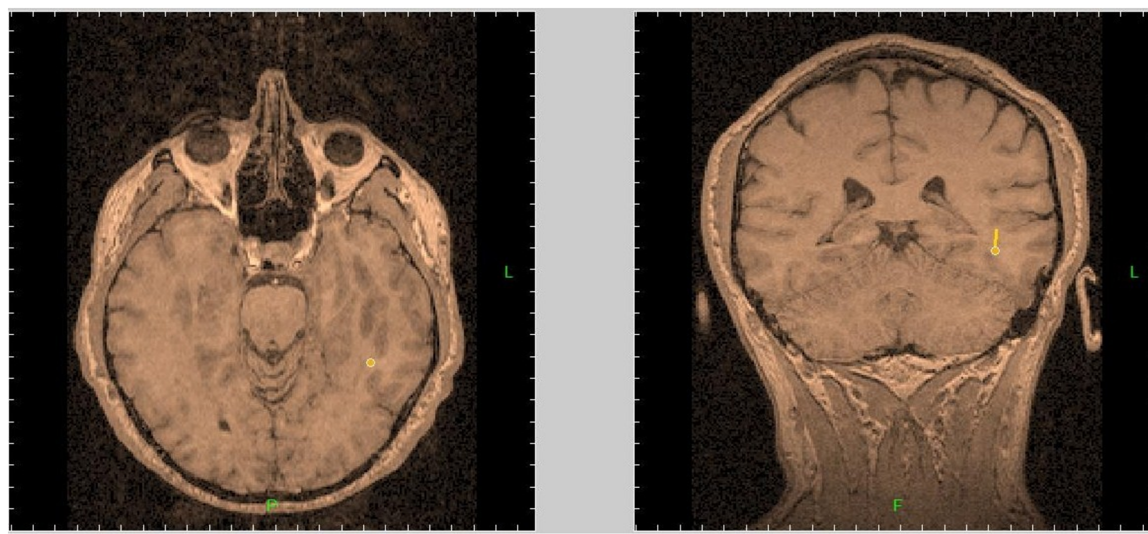
The wavelet coefficients in the Haar basis

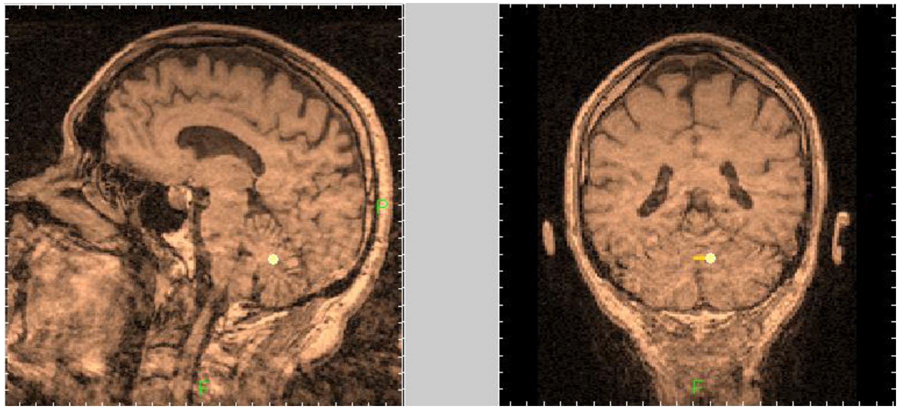
Localization of the source feeding the audio stimulus

localization of the magnetic field source at 10 Hz

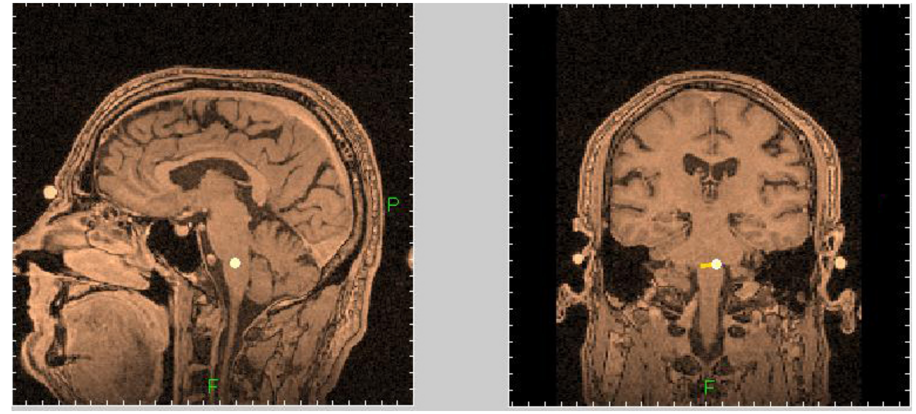


20 Hz

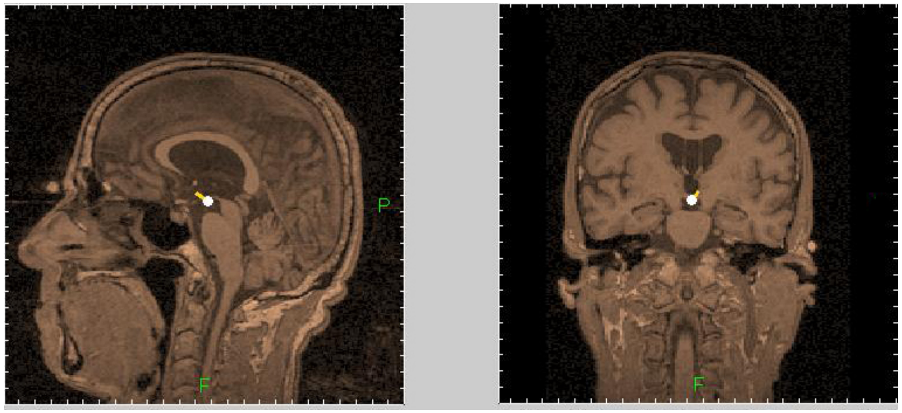




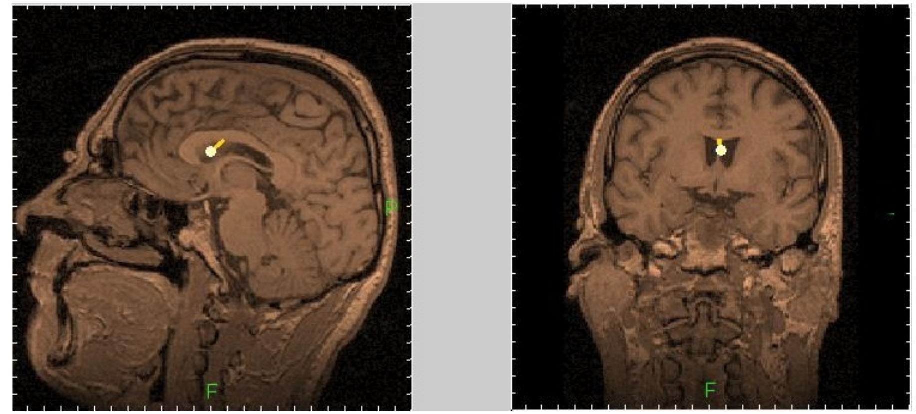
a source in the cerebellum



… in the brainstem (pons)



… in substantia nigra

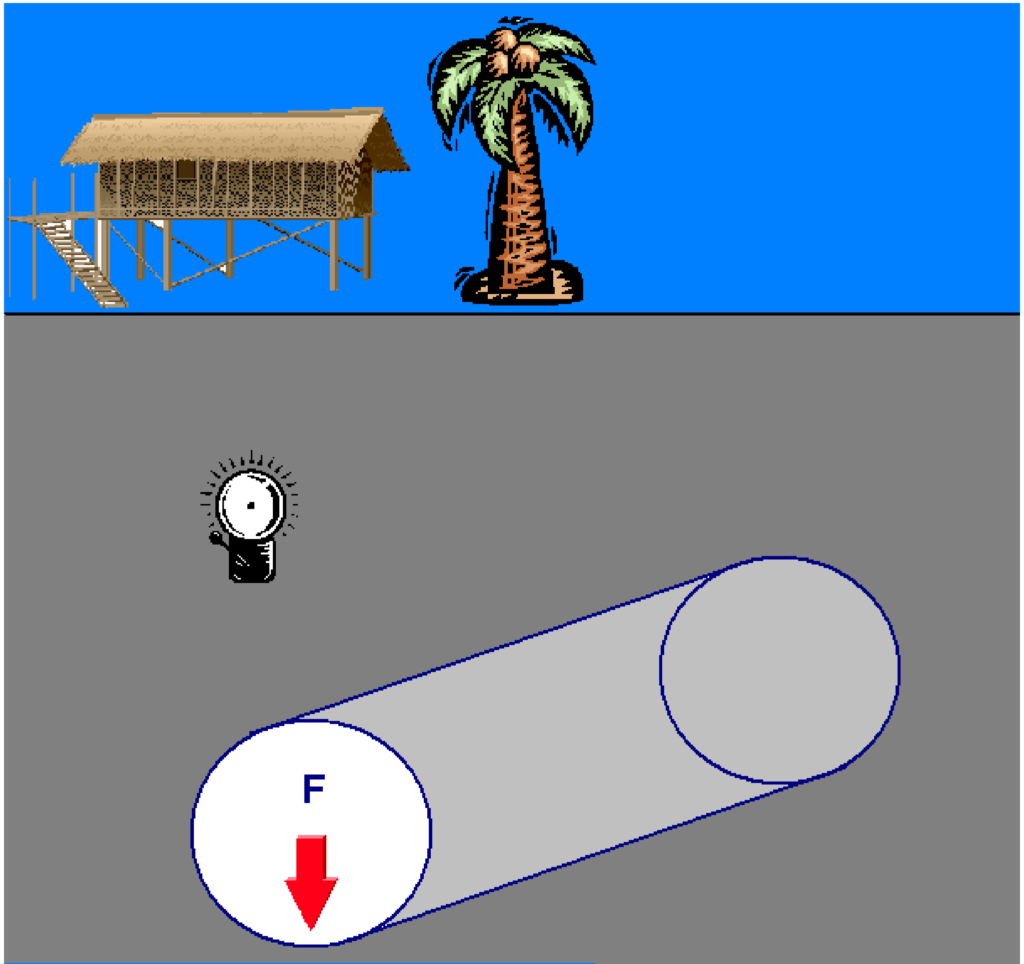


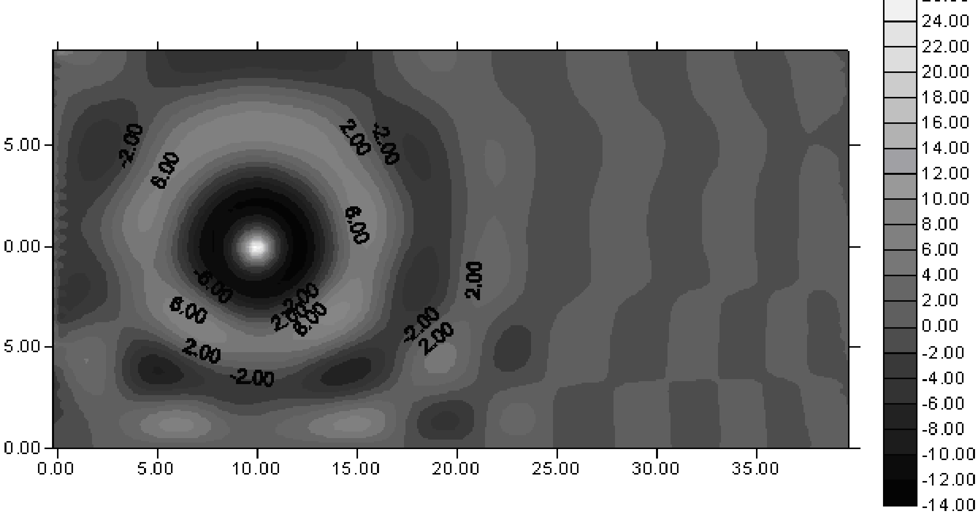
… in the caudate nucleus

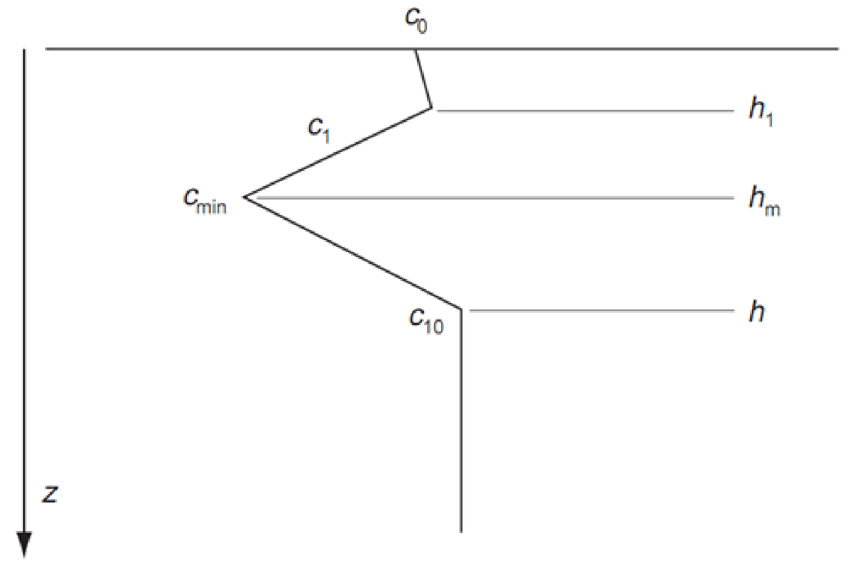
Parkinsonism

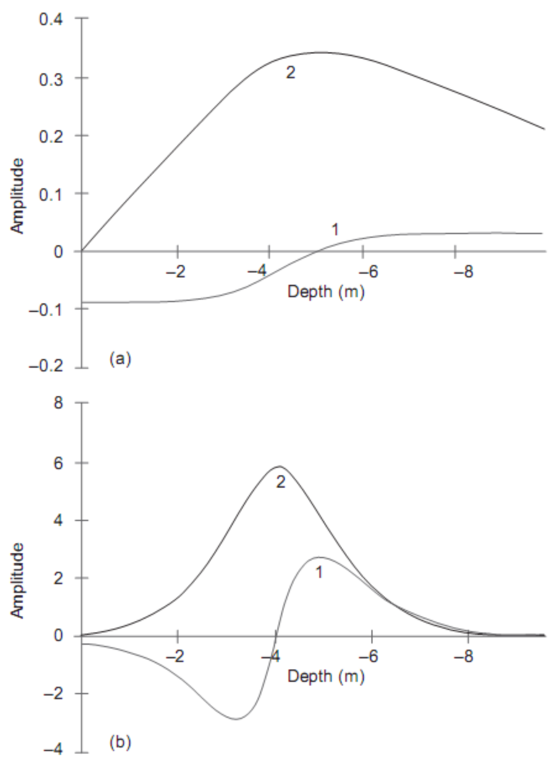
Vibro-acoustic ecology of the city

The problem of vibro-acoustic control









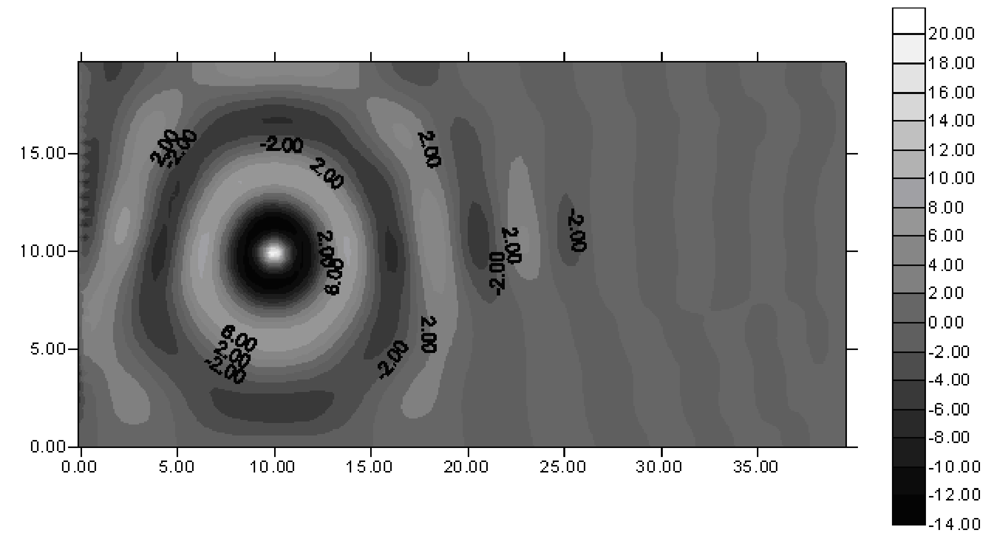
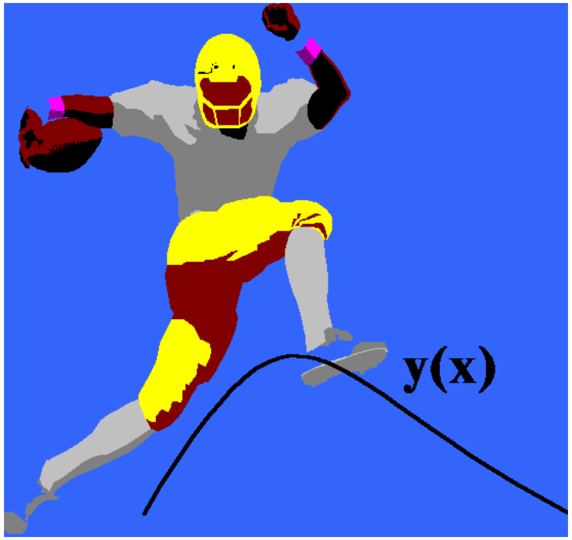


Fig. 13.5. Dependence of the vibration acceleration (curve 1) and pressure (curve 2) on depth (in relative units): (a) f = 31.5 Hz; (b) f = 125 Hz

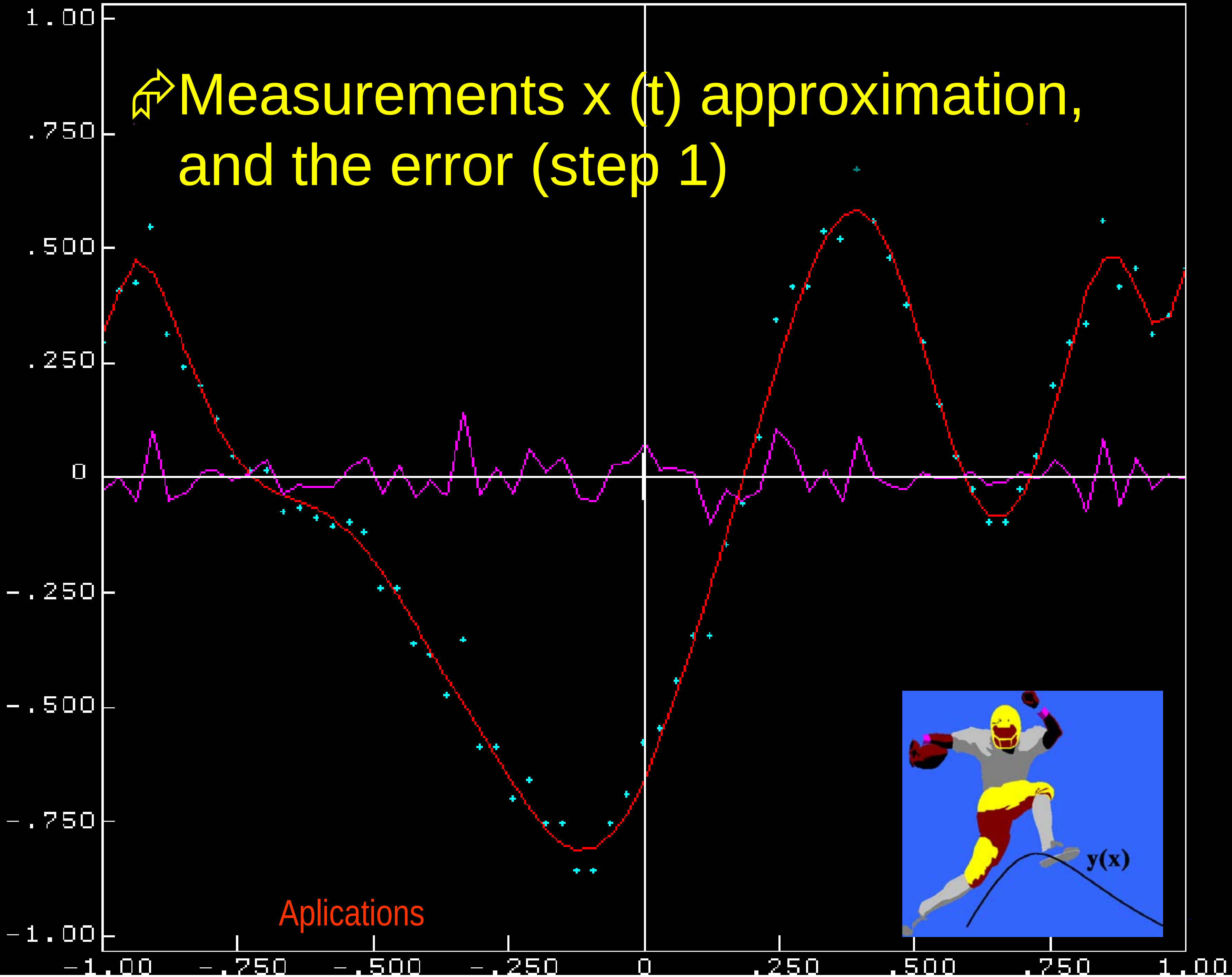
Biomechanical data analysis

- Kinematics of human body

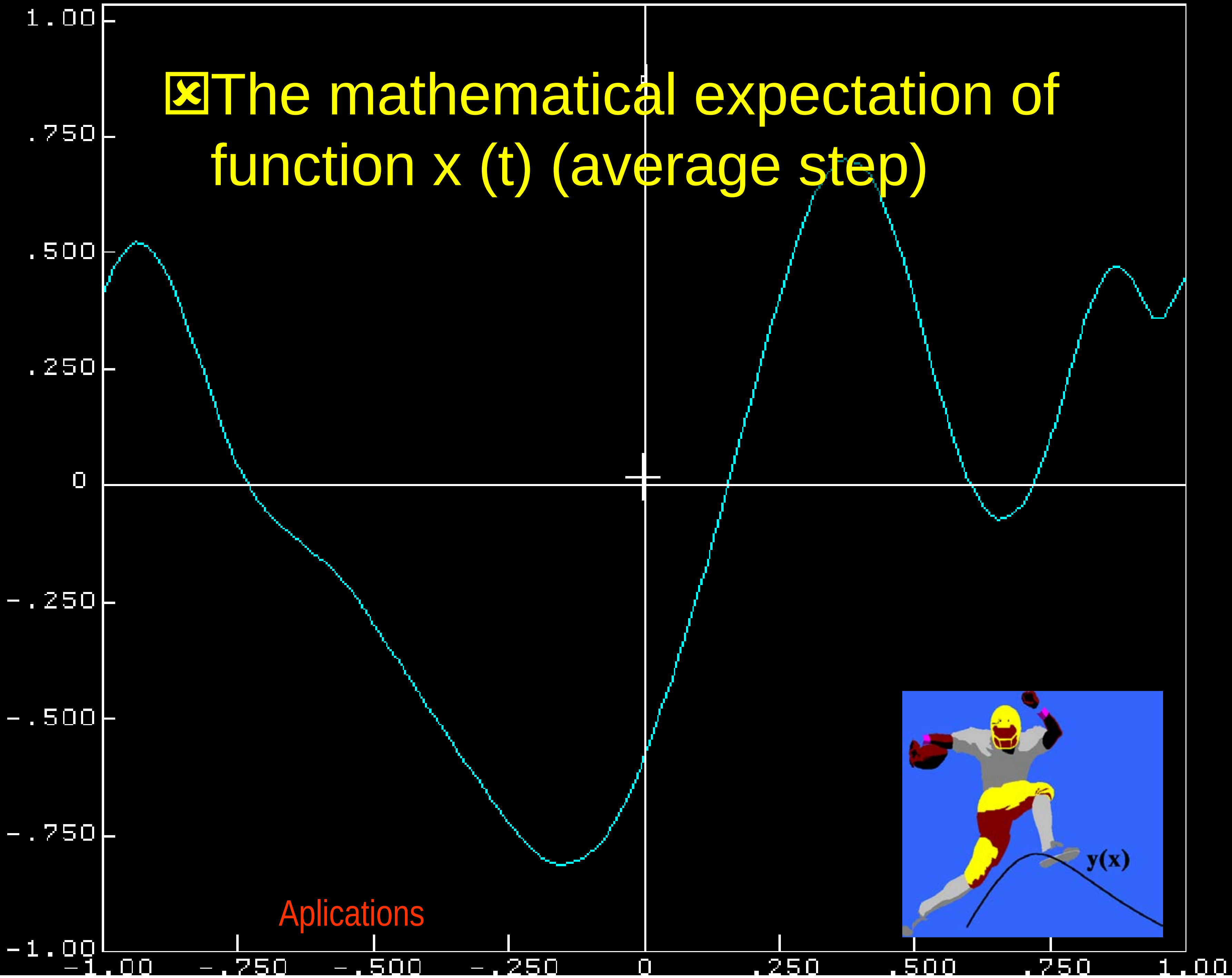
Aplications



Measurements x (t) approximation, and the error (step 1)

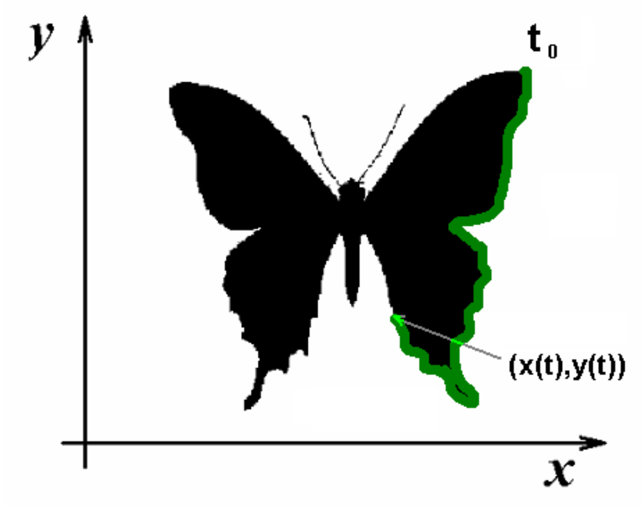


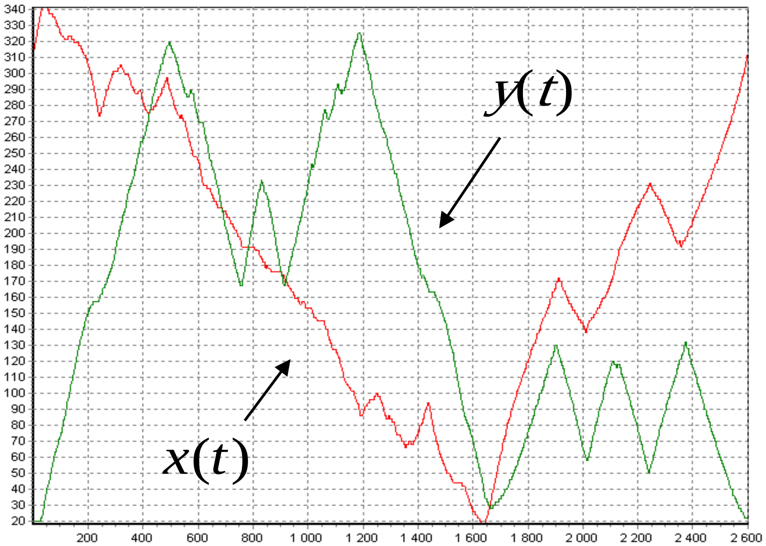
⊠The mathematical expectation of function x (t) (average step)



Aplications

Example of parametric description



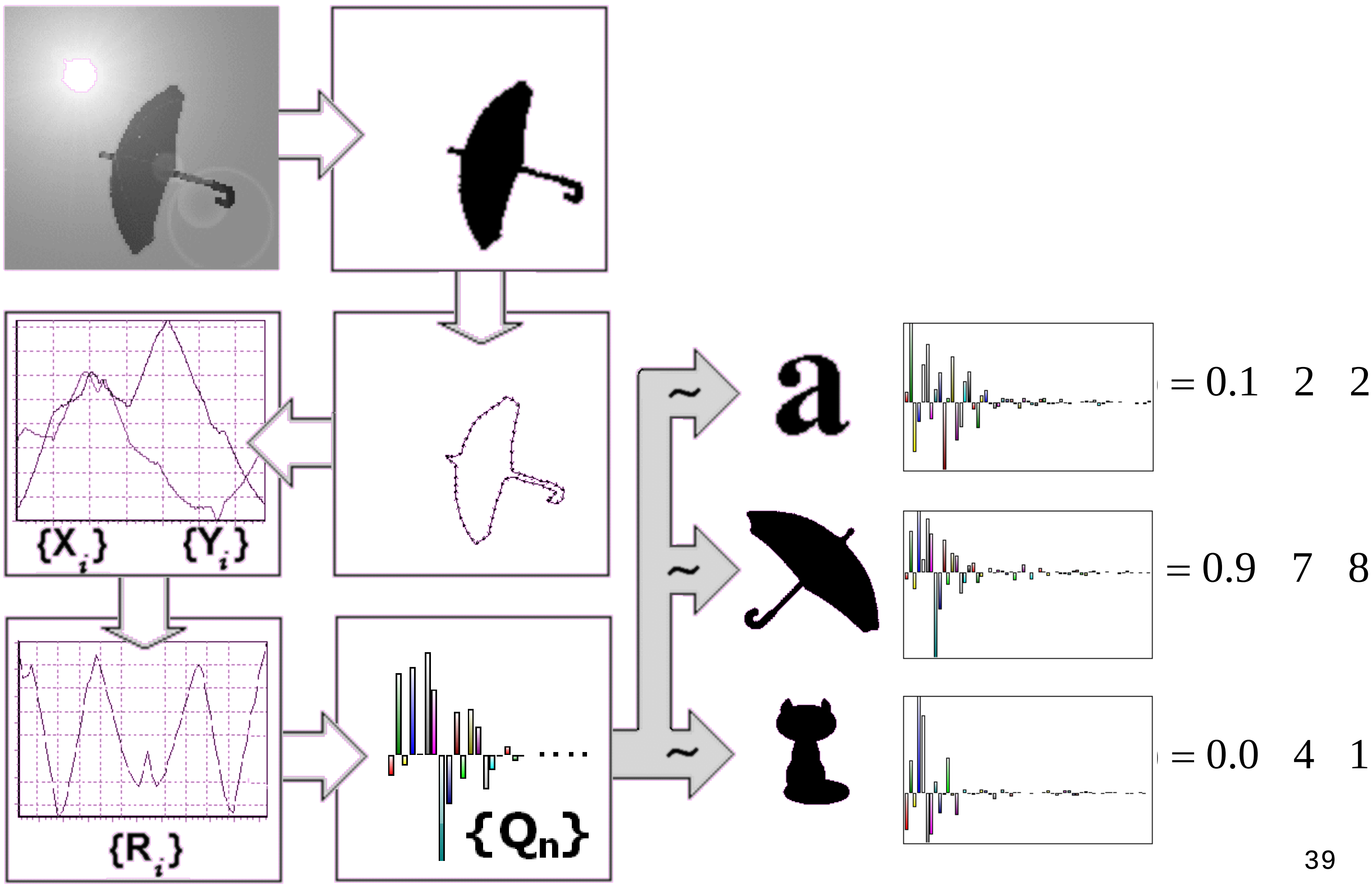


	0	1	2	3	4	...	
A_n	91.2	568	141	−148	−30		$\sum_{n=1}^{N}\sqrt{A_n^2+B_n^2}$
B_n	76.6	−318	342	−107	−68		
$\sqrt{A_n^2+B_n^2}$		651	370	182	74.7		1317

$$x(t)=\sum_{n=0}^{N} A_n\varphi_n(t);$$

$$y(t)=\sum_{n=0}^{N} B_n\varphi_n(t).$$

The general scheme of objects comparison



Coclusions

The information technology solves the following tasks:

- analytical description of the different nature signals
- spectral data conversion using the developed mathematical libraries
- systems assessment and recognition of abnormal behavior
- time series analysis and the search for sites with desired properties
- noise filtering, direct and reverse integral-differential problems solving

Děkuji za pozornost!