MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
KHARKOV NATIONAL UNIVERSITY OF RADIOELECTRONICS

ISBN 966-659-088-3

Proceedings of East-West Design & Test Workshop (EWDTW'04)

Yalta, Alushta, Crimea, Ukraine, September 23 – 26, 2004

CONTENTS

REPRODUCING KERNEL HILBERT SPACE METHODS FOR CAD TOOLS

CHUMACHENKO S.V., KHAWAR PARVEZ, GOWHER MALIK

Kharkov National University of Radio Electronics, Ukraine, 61166, Kharkov, Lenin ave, 14, tel. 70-21-326, e-mail: ri@kture.kharkov.ua

Abstract. The review of known RKHS-methods for analysis of current state in science investigations is represented. The place of Series Summation Method in Reproducing Kernel Hilbert Space (RKHS) is determined. The new results obtained by this method are discussed.

Keywords: Reproducing Kernel Hilbert Space (RKHS), RKHS-methods, Series Summation Method.

1. Introduction (Review)

Reproducing Kernel Hilbert Space (RKHS) methods are interesting both pure theoretically and applied. RKHS theory has been a well studied topic, stemming from the original works of [**1**] to more recent studies on their application by [**2, 3, 8-11**]. Mathematical models based on RKHS and causal operators are presented in [**3**]. They are used at Pattern Recognition [**4**], Digital Data Processing [**5**], Image Compression [**6**], Computer Graphics [**7**]. Mentioned directions are described by mathematical tool – *theory of wavelets* [**4**].

RKHS methods are base tool in *exact incremental learning* [**8**], in *statistical learning theory* [**2, 9**]. The general theory of reproducing kernels which is combined with linear mappings in the framework of Hilbert spaces is considered in [**2**]. A framework for discussing the generalization ability of a trained network in the original function space using tools of functional analysis based on RKHS is introduced in [**8**]. Special kind of kernel based approximation scheme is also closely linked to *regularization theory* [**10**] and *Support Vector Machines* based approximation schemes [**11**] (Fig.).

2. Application Series Summation Method in RKHS

In the mentioned data domains RKHS theory isn't used as a mathematical tool for series summation. However based on separate positions of theory RKHS [**12**] the new approach to definition of sum series is proposed which called Series Summation Method in RKHS [**13, 22**]. It allows analytically to obtain alternative representations for some kind series in the finite form. The new formulas for calculating the sum of alternating series have been obtained by the proof of several theorems [**13, 22**]. The review of known methods for comparative analysis [**16-21**] of the results obtained is represented in [**13**]. Also with usage this new method some integral identities have been proved [**14**], summatory and integral equations have been solved [**15**] (See

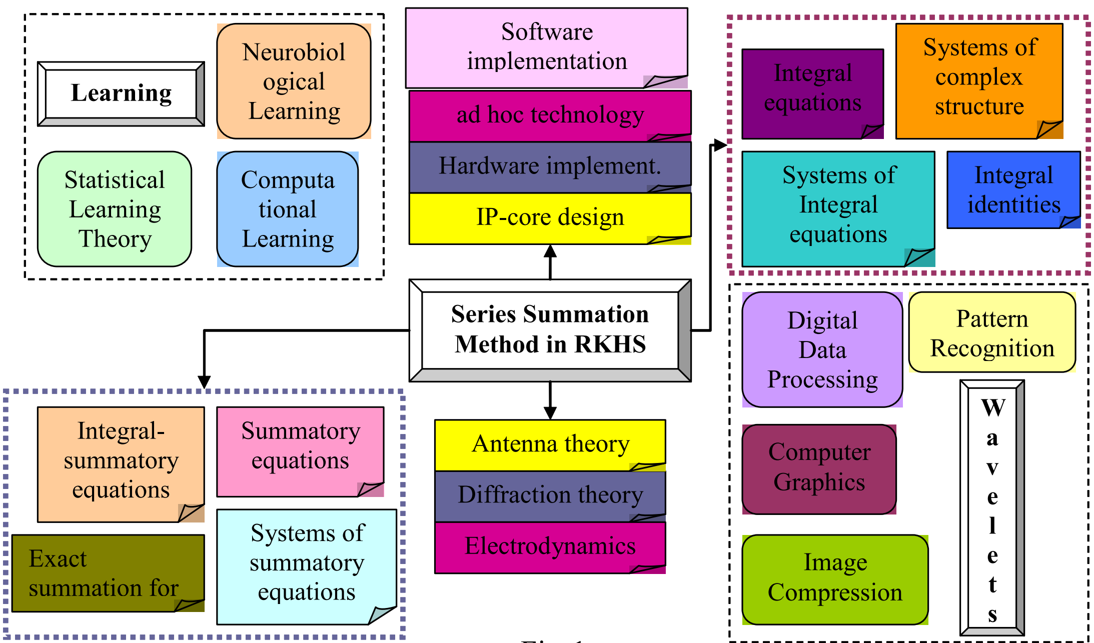


Fig. 1

fig.). Base kinds of kernels used in proposed investigations are represented in Table 1. Functions $Ker_i(s,t)$ form the reproducing kernels for the according Hilbert spaces. Table 2 shows how these reproducing kernels look graphically. The s and t axis represent the variables of the bi-variate reproducing kernel function and z axis shows the value taken these functions.

3. Results

Thus carried theoretical investigations allow to obtain the following *results* having *scientific and practice means*:

1) the solution of summatory equations relatively unknown coefficients which define electromagnetic field in diffraction problems has been found [15];

2) the solution of integral equations which are interesting for some important electrodynamics problems has been found [15];

3) new integral identities have been proofed [14];

4) *Practice significance* of obtained results is defined by its usage in mathematical apparatus at solving mentioned above problems namely: application proposed method at synthesis and analysis of radio electronics and computers equipments; saving of time and cost of calculations as a result of velocity increasing calculations of some types series; possibility of apparatuses realization of methods that allows to increase calculation processing speed.

1. The obtained results can be included into the reference mathematical library and also implemented into Mathematics, MathCAD, Math Lab means. It can be useful for scientists, engineers, mathematics at solving the different problems of mathematical physics.

2. Developing the new technology in microelectronic and schematic design connected with mathematical calculations and increasing

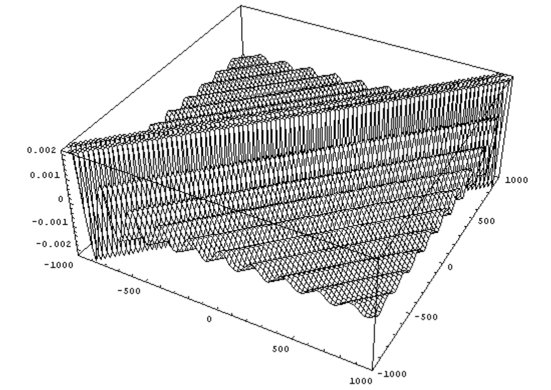
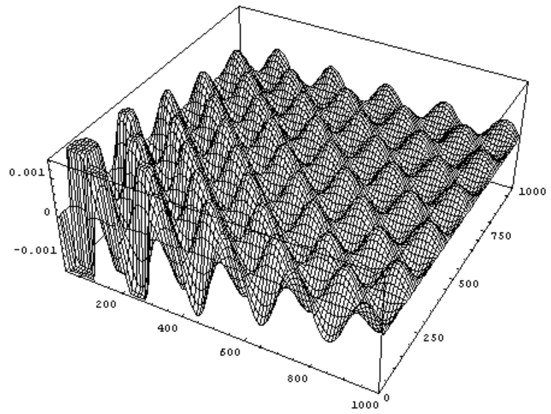
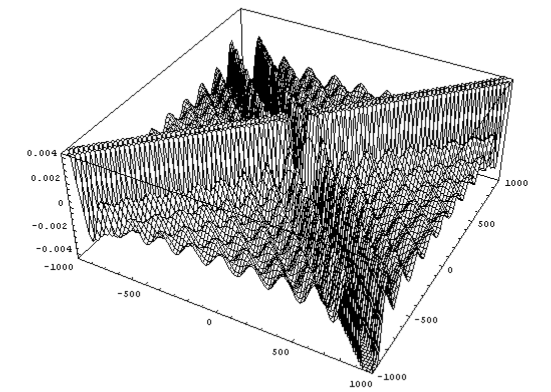
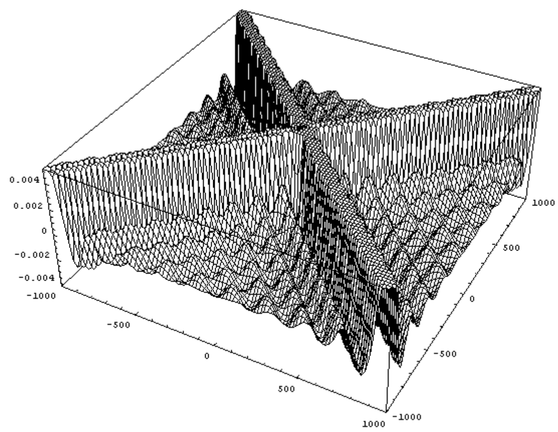
Table 1.

Kinds of Kernels, determining RKHS

Kernel	RKHS	Functions f (elements of RKHS)	Series on selective velues
$Ker_1(s,t)=\frac{\sin\pi(t-s)}{\pi(t-s)}$	H_1	Fourier-transformation $F(\omega)=\lim_{A\to\infty}\int_{-A}^{A} f(t)e^{-i\omega t}dt$ is finite on the interval $(-\pi,\pi)$.	$f(s)=\sum_{k=-\infty}^{\infty} f(k)\frac{\sin\pi(s-k)}{\pi(s-k)}$, $-\infty<s<\infty$
$Ker_2(s,t)=\frac{\pi(ts)^{1/2}}{s^2-t^2}\times$ $\times[tJ'_\nu(s\pi)J_\nu(t\pi)-$ $-sJ_\nu(t\pi)J'_\nu(s\pi)]$	H_2	Hankel-transformations of order $\nu\ge 1/2$ $F(\omega)=\lim_{A\to\infty}\int_0^A(\omega t)^{1/2}J_\nu(\omega t)f(t)dt$, $0<t<\infty$, are finite on the interval $(0,\pi)$. Fourier-Bessel retransformation $f(t)=\int_0^\pi(\omega t)^{1/2}J'_\nu(\omega t)F(\omega)d\omega$.	$f(s)=\sum_{k=1}^{\infty} f(t_k)\frac{2(st_k)^{1/2}}{\pi J_{\nu+1}(\pi t_k)}\frac{J_\nu(\pi s)}{(t_k^2-s^2)}$, $0\le s<\infty$
$Ker_3(s,t)=\frac{1}{\pi}\times$ $\times\left(\frac{\sin\pi(t-s)}{t-s}-\frac{\sin\pi(t+s)}{t+s}\right)$	H_3	Sine - transformation $F(\omega)=\lim_{A\to\infty}\left(\frac{2}{\pi}\right)^{1/2}\int_0^A f(t)\sin\omega t dt$, $0<t<\infty$, is finite on the interval $(0,\pi)$. Inverse sine - transformation: $f(t)=\left(\frac{2}{\pi}\right)^{1/2}\int_0^\pi F(\omega)\sin\omega t d\omega$.	$f(s)=\sum_{k=1}^{\infty} f(k)\frac{2k}{s+k}\frac{\sin\pi(s-k)}{\pi(s-k)}$, $0<s<\infty$
$Ker_4(s,t)=\frac{1}{\pi}\times$ $\times\left(\frac{\sin\pi(t-s)}{t-s}+\frac{\sin\pi(t+s)}{t+s}\right)$	H_4	Cosine - transformation $F(\omega)=\lim_{A\to\infty}\left(\frac{2}{\pi}\right)^{1/2}\int_0^A f(t)\cos\omega t dt$, $0<t<\infty$ is finite on the interval $(0,\pi)$. Inverse cosine-transformation: $f(t)=\left(\frac{2}{\pi}\right)^{1/2}\int_0^\pi F(\omega)\cos\omega t d\omega$.	$f(s)=\sum_{k=0}^{\infty} f(k)\frac{\varepsilon_k s}{s+k}\frac{\sin\pi(s-k)}{\pi(s-k)}$, $0<s<\infty$

Table 2

Reproducing Kernels for functional spaces H_i

RKHS	Graph
H_1	
H_2 $(\nu = \frac{1}{2})$	
H_3	
H_4	

computer speed up. CPU as universal processing unit can solve broad spectrum of various tasks from all areas of human activity. Nevertheless there are exist bottlenecks where CPU can't satisfy required performance. Usually it happens during implementation of mathematical tasks that require big number of iterations and hence big time expenses to obtain desired result with desired accuracy.

3. To increase efficiency of solving of computational tasks there are used mathematical co-processors. There implemented most efficient ways of computing equations, integrals, differential coefficients. It is obvious that after discovering of new methods of increasing computation accuracy and decreasing computation time it is necessary to re-implement mathematical co-processors or use new generation of IP-cores in PLD, Gate Array, ASIC designs.

4. It is presented, easy to implement as IP-core, method of reduction of computation of certain types of series to exact function, that is widely used during calculation of parameters of high radio frequency devices. Presented method decrease computation time of such tasks in tens and hundred times and its inaccuracy is equals to zero.

References: 1. *Aronzajn A.* Theory of reproducing kernels // Trans. American Math. Soc., 68:337-404, 1950. **2.** *Saitoh S.* Integral Transforms, Reproducing Kernels and Their Applications, Pitman Res. Notes in Math. Series, **369** (1997), Addison Wesley Longman, UK. **3.** *Laslo Mate.* Hilbert Space Methods in Science and Engineering, 1990, 200 p. **4.** *Daubeshies I.* Ten lectures on wavelets. CBMS-NSF. Regional conference series in applied mathematics. SIAM, Philadelphia, 1992. **5.** *Короновский А., Храмов А.* Непрерывный вейвлетный анализ и его приложения. М.: Физматлит, 2003. 176 с. **6.** *Уэлстид С.* Фракталы и вейвлеты для сжатия изображений в действии / Пер. с англ. М.: Триумф, 2003. 320 с. **7.** *Столиц Э., Дероуз Т., Салезин Д.* Вейвлеты в компьютерной графике. Теория и приложения / Пер. с англ. Москва-Ижевск: НИЦ «Регулярная и хаотическая динамика», 2002. 272 с. **8.** *Sethu Vijayakumar, Hidemitsu Ogawa.* RKHS based Functional Analysis for Exact Incremental Learning / Neurocomputing: Special

Issue on Theoretical analysis of real valued function classes, Vol.29, No.1-3, pp.85-113, Elsevier Science (1999) / http://www-clmc.edu/sethu/research_detail.1html. **9.** *Saitoh S.* New Norm Type Inequalities for linear mappings // Jornal of Inequalities in Pure and Applied Mathemathics. Victoria Univ., 2003. Volume 4. Issue 3. Article 57. http: // jipam.vu.edu.au. **10.** *Girosy F.* An equivalence between sparse approximation and support vector machines // Neural Computation, 10(6): 155-1480, 1998. **11.** *Vapnik V.* The nature of Statistical Learning Theory. Springer-Verlag. New York, 1995. **12.** *Functions* with double orthogonality in radio electronics and optician / By edition Ì.Ê. Razmahnin and Â.P. Yakovlev. M.: Sov. radio, 1971. 256p. (in Russian). **13.** *Chumachenko S.V.* Summation method of selected series for IP-core design // Радиоэлектроника и информатика. 2003. №3. С. 197-203. **14.** *Чумаченко С.В.* Теоремы о некоторых интегральных тождествах на основе метода суммирования рядов в ГПВЯ // Радиоэлектроника и информатика. 2004. №1. С. 113-115. **15.** *Чумаченко С.В.* Гильбертовы пространства с воспроизводящими ядрами и некоторые их применения // Радиоэлектроника и информатика. 2003. № 4. С. 141-144. **16.** *Tranter C.J.* Integral Transforms in Mathematical Physics. London: Methuen & Co. Ltd., New York: John Wiley & Sons, Inc. 1951. **17.** *Doetsch G.* Anleitung Zum Praktischen Gebrauch Der Laplace-transformation und Der Z-transformation. R. Oldenbourg. Munhen, Wien, 1967. **18.** *Angot A.* Complements de Mathematiques. A L’usage Des ingenieurs de L’elektrotechnique et Des Telecommunications. Paris, 1957. **19.** *Watson G.N.* A Treatise on the Theory of Bessel Functions. Cambridge: Cambridge University Press. 1952. **20.** *Òitchmarch Å.C.* The theory of functions. Oxford Univ. Press, 1939. **21.** *Àhiezer N.I.* The lectures of the approximating theory. Moscow: Nauka, 1965. 408p. (in Russian). **22.** *Chumachenko S.V., Govhar Malik, Imran Saif Chattha. Series Summation Method in HSRK* // Proc. of the international Conference TCSET’2004 “Modern Problems of Radio Engineering Telecommunications and Computer Science”. February 24-28. 2004. Lviv-Slavsko, Ukraine. P.248-250.

ELECTRICAL TEST IS NOT ENOUGH FOR QUALITY

BENGT MAGNHAGEN

JONKOPING UNIVERSITY, SWEDEN

bengt.magnhagen@ing.hj.se

Electrical test means Functional Test (FT), In Circuit Test (ICT) or Boundary Scan Test (BST) or even a combination of these technologies. However, with modern technology, like SMD (Surface Mounted Devices) technology, BGA (Ball Grid Array) components and extremely small component dimensions, electrical test alone does not meet the quality requierments.

Electrical test can not identify bad soldering and bad alignment of components, as examples. Missing decoupling capacitors and so on can not be detected because of it is hard to get physical access for testprobes. Do not forget that digital designs contains a lot of analogue devices!

The tutorial will discuss today test technology with equipment for ICT and BST as well as its pros and cons. And as the addition of this, Inspection. Inspection has traditonally been performed manually but this is not realistic today with board crowded by components. Today Inspection is performed by machine vision. Optical technique named Automated Optical Inspection (AOI) and more advanced X-ray inspection (AXI). AOI and AXI is not the future, it is here today.

EMC /EMI is also a growing challenge and some new ideas will be discussed how to test for these phenomenas.

Підписано до дру*у 9.09.т004. Формат 60*84$^{1}/_{8}$.

Умов. дру*. ар*. ууи4. Облі*.-вид. ар*. у0и0. Зам. № т-875. Тираж №0 прим.

Віддру*овано в навчальнофнау*овому видавничофполіграфічному центрі ХНУРЕ.

6№66иХар*івипросп. Ленінаи№4.