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Plenary Lecture 1

Density and Approximation by Radial Basis Functions

Professor Vitaly Maiorov

Abstract: We characterize the radial basis functions whose scattered shifts form a fundamental system in the space $L_p(\mathbb{R}^d)$. In particular, we show that for any even function h from the space $L_2(\mathbb{R},\mu)$, the space formed by all possible linear combinations of shifted radial functions $h(\|x+a\|)$, $a\in\mathbb{R}^d$, is dense in the space $L_p(\mathbb{R}^d)$, $1\le p\le 2$, if and only if the function h is not a polynomial. The problems of approximation by radial basis functions also are discussed.

In order to obtain our results we make use of methods of harmonic analysis on the unit ball B^d which are based on a combination of methods of harmonic analysis on the unit sphere $\mathbb{S}^{d-1}$ and the unit segment $\mathbb{U}:=[-1,1]$. Using an orthogonal basis of spherical harmonics on $\mathbb{S}^{d-1}$ and the Gegenbauer basis of orthogonal polynomials on the segment $\mathbb{U}$ we construct a new basis $\mathbf{P}=\{P_n\}$ ('convolution' of bases on $\mathbb{S}^{d-1}$ and on $\mathbb{U}$) consisting of orthogonal polynomials on the ball B^d. The peculiarity of the basis $\mathbf{P}$ is that the moments $M_a(g,a):=\langle g_a,P_n\rangle$ of radial functions of the form $g_a=g(\|x+a\|)$ in some sense allow for a separation of the variables g and a. That is, we represent them by the finite sum $M_a(g,a)=\sum_k u_k(g)v_k(a)$, where $u_k(g)$ are a linear functionals of g and $v_k(a)$ are a functions on $\mathbb{R}^d$.