



The development of approximation theory and some proposed applications

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Abstract

In this survey article, we review the early history of approximation theorem that was introduced by Weierstrass in the late 18th century, together with its extension works. We also propose some applicable scenarios that best fit this theory. Such applications include the kinetics conditions related to manual and automatic vehicle transmission by using convex function, and the theory of calculating deviations of eye's layers (normal vision, hyperopia and myopia) in some patients by using monotone function.

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1. Scope of the survey

In this survey, we present a historical overview of the approximation theory and its development over time. Then, we provide some open problems of approximation theory in mechanical engineering and ophthalmology, through examples in gear transmission and medical optics. These are pragmatic applications, given the centrality of vehicular mobility and human sight to improve the quality of life.

2. Review of the development of approximation theory

We begin by giving a broad perspective of approximation theory. It was created to provide value for the methods of infinite limitisation qualitatively and quantitatively. It was founded based on mathematical model provided by mapping, function, number and set, which contributed to understanding the problems of quadrature in approximation theory. The aim of approximation theory is to introduce and provide computation in theoretical mathematics. Such computational advantages is able to number operations including division, multiplication, inversion of a matrix, best polynomials and solution for equations [1]. In fact, if the word "approximation theory" is used, this term refer to more divisions in mathematical analysis, which was developed as a result of the works by Chebyshev (1853), Weierstrass (1885), Lebesgue (1898), Bernstein (1952, 1937), Nikol'skij (1945), Kolmogorov (1985) and followed by many of their followers such as [2], and [3]. The direction of approximation theory (e.g. functions by trigonometric, algebraic polynomials, splines, rational functions and estimates approximation on smooth functions), is not limited to technical sciences only. It is also relatable to practical human activities, such as the theory of mechanisms in steam engines. The applications highlighted by Chebyshev's works are notable examples of this practical application.

In the early work of approximation theory, the number II that was developed by Euler (1747) was known as the period of approximation theory. By diverting their attention to mathematical analysis, Euler (1747), Bernoulli (1694), Kepler (1615), Newton (1665) and Lagrange (1898) developed methods to approximate numbers, operators and functions in the form of solutions for equations. However, Gauss (1886) popularising approximation theory by developing methods for optimal computation of integrals and solutions of equations. He also developed an approximation theory in the metric of the quadratic function. Later, Chebyshev (1853) developed methods for optimal approximations of abundant concrete functions [4].

In the era of modern technology however, many of his published works only gain historical interest. Nonetheless, it is important to note that the significance of Chebyshev's work had turned out to have wider pragmatic application. Such extension enabled a new direction in functional analysis, whereby research topics expanded towards algebraic polynomial and best approximation, to name just two area of interest. The complexity of functions approximation by means of polynomials are the core of the first stage of Chebyshev's work on approximation theory (see [5] and [6]). Gradually, this practical direction (better known as the second stage in approximation theory) describes the purely theoretical problem for the drawn properties of functions by the usage of their approximative characteristics. These include functions such as the Fourier and Taylor coefficients, Padé approximation and best polynomial approximation.

The third stage in the development of approximation theory focused on approximative possibilities of the algebraic and trigonometric polynomials and rational fractions. The works in this third phase include Kolmogorov [3] such that a new viewpoint on classical

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