Preface

The central theme of this book is the Gibbs derivative, a broad class of differential operators the most prominent member of which is the Butzer-Wagner derivative. The goal of the book is to introduce researchers in applied mathematics, information sciences, computing, and related areas to this particular concept in dyadic analysis and various generalizations of it.

The rationale, and hopefully an excuse, for bringing it to public notice, is a feeling that due to the present situation in information sciences and related technology, there can be a room for some concrete applications of these differential operators. This situation can be briefly summarized as follows.

The information and computing technologies are currently faced with problems in further exploiting approaches which were used in the last couple of decades for developing computing hardware based on semiconductor devices since their physical limits have been nearly reached. There can be observed some similarity with the situation in early seventies when Walsh dyadic analysis emerged as an answer to demands for improving performances in performing certain, primarily signal processing related, algorithms by changing the underlying mathematical foundations, since the limited computing power of hardware available at the time could not provide acceptable solutions based on classical theories.

The information sciences, with this term understood in a broad sense, are continually challenged to provide answers to demands for processing ever increasing amounts of data. Extracting and processing the content data contain is possible only by extensive use of computing hardware that is being constantly improved and performance enhanced. Therefore, for both computing technologies and information sciences, there is a need for essentially new discoveries possibly based on alternative approaches to those currently used. There is again a similarity with introducing the Walsh dyadic analysis in former times as an alternative to classical Fourier analysis in certain applications.

Differential operators, as introduced by Newton and Leibniz, can be generally viewed as a tool for estimating the rate and the direction of change of signals. The Gibbs derivatives were introduced over 45 years ago to serve the same purpose in information sciences as the Newton-Leibniz derivative does in mathematical physics and related areas [1]. Therefore, these differential operators can be viewed as an alternative to the existing differential operators tailored for application in Walsh dyadic analysis and extedning the classes of functions differentiable in certain sense.

At that time, Walsh (Fourier) analysis had attracted much attention for two reasons. First, it enjoyed peculiar properties (being a bounded, piecewise constant orthonormal system), and second, its coefficients and transforms could be easily and efficiently computed (since it took on only the values ± 1). These properties gave the Walsh system quite an important advantage over the classical Fourier analysis regarding the available computer hardware.

The Gibbs derivatives were introduced as differential operators having Walsh functions as their eigenfunctions. It might be said that these operators were intended to provide a mathematical tool offering advantages of differential operators primarily taking into account demands for processing of binary encoded signals, but also the computing power offered by the technology at the time. Therefore, interest in Walsh analysis, in general especially discrete Walsh analysis, and in the Gibbs derivatives in particular, can be explained by two reasons. First engineering practice required fast implementation of various algorithms for signal and information processing based on spectral (Walsh-Fourier) analysis, and second the limited computing power of the technology at the time ultimatively demanded something that took less memory than older, more established classical Fourier analysis.

For these reasons, regarding the present situation, we believe that the way of thinking that led to this concept can be equally useful in defining new concepts and related methods in computing with applications in signal and information processing now and in future.

To serve its goal, the book contains reprints of several papers setting the foundations of Gibbs differential operators in general, and the Butzer-Wagner derivative in particular, as well as some generalizations of these concepts.

Reprinting original former publications instead of rewriting the main theory, is motivated by the following considerations.

By taking the line of development of Walsh analysis as a computationally less demanding mathematical foundations for signal processing algorithms into account, we did not want to rephrase or rewrite the original statements in early papers on this subject for two reasons. First, we believe that the way these statement were presented originally by the authors, has a particular value for the reader. Second, the manner of writing and the way of formulating and discussing certain important concepts often reflects both the fashion of the times as well as the authors attitude to the subject. This, in a way, also expresses other circumstances at the time when the notions were introduced and concepts and theories formulated.

Therefore, we did not dare disturb and destroy the initial composition of the contents and their formulation, as done by the authors, by rewording the statements in present terminology. Thus, we restricted the contribution on our part to the selection of what we consider most interesting to present to the readers notice.

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[1] Gibbs, J.E., "A contribution to a revolution?" *NPL News*, 1971 May, 1-4, (1971).
It is meant the informatics revolution that started at about that time (remark by editors)

Taking this into account, the reprinted papers are selected by the following criteria.

We wanted to reprint papers in which important results in this area were initially introduced and discussed. Most of these papers were presented at workshops which make them not so easily accessible. That was another motivation to reprint them rather than more elaborated versions that were possibly published latter in some journals. We also wanted to present papers which suggested alternative approaches to the Gibbs differentiation, proposed particular extensions and generalizations of the concept, or discussed certain applications.

The reprinted papers shuld serve as a basis for reading newly written chapters reviewing former and presenting recent and new results in the area. These chapters provide reviews of particular aspects of the theory of Gibbs differentiation and are written mostly by the founders of this theory. The book includes discussions of recent developments in the area as well as a collection of open and unsolved problems. Attempting to provide a rather complete picture of the development in the field, we asked the contributors to this book who started their research in the field in seventies and eighties for their reminiscences of personal involvement in the subject.

With a hope that the book will serve its purpose, we thank all the contributors as well as other friends without whose help its appearance would hardly be possible.

Acknowledgments

The four editors of this monograph, in particular Radomir S. Stanković and Paul L. Butzer, express their thanks for its preparation to the authors of the monograph together with their former students. The initiator of dyadic differentiation, James Edmund Gibbs, National Physical Laboratory, Teddington, UK, died much too early, in January 2007, and so could, most unfortunately, not participate in our present project.

Mrs. Merion Gibbs reported that according to her husbands diary, his first definition of his ”logical derivative” was written in January 1967. Of his 27 publications on dyadic derivatives six were written together with Dr. Brian Ireland, Bath University, UK, who joined Dr. Gibbs in the work on this subject in 1971.

The joint work of authors towards the present monograph, which took place over a period of almost four years, was very constructive and unbelievably harmonious, and even during the time from 1969 until 1990 when the chief results of dyadic Walsh analysis were developed by them. This is by no means self-evident since the authors come from ten countries, namely Austria, Canada, China, England, Germany, Hungary, Japan, Russia, Serbia, USA, with quite different mathematical/scientific traditions.

The majority of these, together with some of their former students, only met for the first time at the Workshop ”Theory and Applications of Gibbs Derivatives”, conducted by Radomir S. Stanković at Kupari- Dubrovnik, Yugoslavia, on September 26-28, 1989.

All authors express their special thanks to Charles Chui, Stanford University, for accepting our monograph as Editor of the series ”Atlantis Studies in Mathematics for Engineering and Science” of Atlantis Press, Paris, without any hesitations. It is quite common for selected or complete publications of one author (which could cover several fields) to appear in book-form. But this is by no means so for selected papers of all founding authors of one field, even together with reader-friendly reviews of their own papers, to appear in book-form. Further, the authors thank Dr. Keith Jones for handling all matters concerned with Atlantis Press, Paris, in an efficient and friendly manner, as well as Springer for production, marketing, and distribution of this book. In particular, thanks are due to Ms. Devi Ignasy, the Project Coordinator, and Ms. Gajalakshmi Sundaram, the Production Editor, from Springer, for excellent processing of the manuscript, especially for very good care of reprinted papers, the source versions of some of them which were not so clear and easily readable.

The Editors

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