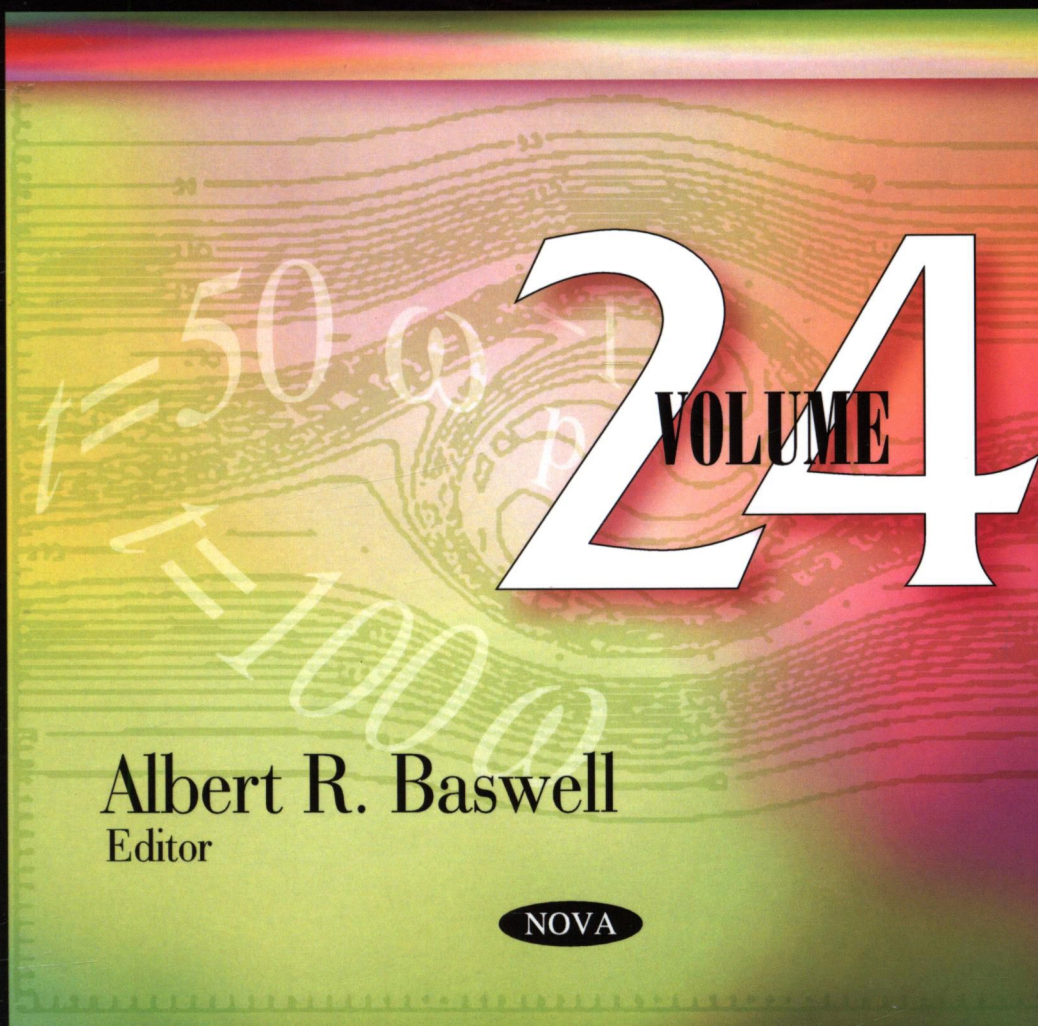
Advances in Mathematics Research



Albert R. Baswell
Editor

NOVA

ADVANCES IN MATHEMATICS RESEARCH

VOLUME 24

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PREFACE

In Chapter One, Ming Ming Chiu deliberates on the way statistical discourse analysis can be used to overcome certain modeling problems by presenting a study on social metacognitive actions. Next, Chapter Two by Oscar João Abdounur explores the correlation between ratio and theoretical music, especially from the 14th through the 16th centuries in Europe. In Chapter Three, Thomas Z. Fahidy provides a review of several textbook literature cases which maintain the significance of choosing testing methods. Following this, Chapter Four by A.V. Kalinin, M.I. Sumin, and A.A. Tyukhtina evaluate issues of final observation for the system of Maxwell equations in the quasi-stationary magnetic approximation. Additionally, they present possible algorithm applications. In Chapter Five, R. Campoamor-Stursberg applies a systematic method to five-dimensional Lie algebras in order to address the problem of nonlinear systems. Chapter Six by Mohamed Sallak, Ayyoub Imakhlaf, and Yunhui Hu suggest the importance of imprecise theories versus the classical probability theory. Lastly, Chapter Seven by Yilun Shang presents a review on current knowledge of groupies in varied random graph models.

In Chapter 1, as sequential analysis models how recent event affect current events as transitions between different states, it can only model relative small numbers of states before facing combinatorial explosion of possible sequences of states. Statistical discourse analysis (SDA) overcomes this problem by analyzing attributes of actions/behaviors rather than states. Thus, SDA can model (a) effects of previous actions and sequences on target actions, (b) pivotal actions that radically change subsequent processes, and (c) influences at various levels (action, time period, individual, group, etc.). Moreover, SDA addresses the following additional issues involving data (unit of analysis,

coding, inter-rater reliability, missing data, parallel conversations, breakpoints, time periods, statistical power), dependent variables (discrete variables, infrequency bias, nested data, multiple dependent variables), and explanatory variables (variables at earlier turns, cross-level interactions, indirect multilevel mediation, serial correlation, false positives, odds ratios, and robustness). To illustrate SDA, an example analysis shows how social metacognitive actions (e.g., agree, rudely disagree) are linked to the likelihoods of correct, new ideas (micro-creativity) and justifications, based on 3,104 turns of talk by 80 students in 20 tetrads solving an algebra problem.

Chapter 2 investigates interrelationships between theories of ratio and theoretical music originating in Antiquity, with special attention to the period between the 14th and the 16th centuries in Europe. It considers evidence from different theories of ratio and proportion, stressing tendencies in the mathematical treatment of these concepts, which show similarities with music in structure and or terminology and also examines their reflection in music in the period in question. It could be said that from later times and particularly in Book V of Euclid's *Elements*, ratios were seen as a generalization of musical intervals whose nature was clearly distinct from numbers or magnitudes. The change is from conceptions of operations strongly tied to contiguous musical intervals to theories that admit the composition of general ratios with an essentially arithmetic character, for example, the idea that a ratio is equal to a number. It will be investigated here some attributes of these competing theories of ratios, as well as its close relationships with theoretical music up to the 16th century.

As explained in Chapter 3, the normal (Gaussian) distribution is one of the most important (if not the most important) family of continuous random variables. Because of its ubiquity in the statistical analysis of natural, technical, biological, sociological and economic processes, numerous methods have been invented to determine if a string of observations may be considered to be a sample from a normal population, with its sample mean and sample variance serving as unbiased estimators of the (often unknown) population mean and population variance, respectively. Beyond satisfying scientific curiosity, this quest stems from the necessity of normality in order to be able to carry out appropriate tests of hypotheses, and to arrive at certain inferences with firm statistical reliability. For instance, in fitting empirical data with proper mathematical models, the postulation of normally distributed residuals with zero mean and constant variance is a cornerstone tenet of standard regression analysis. The conventional chi-square method and the Kolmogorov-

Smirnov method are regular inclusions in most textbooks of statistical literature.

There has been mounting evidence since the 1970's for the limited reliability of certain conventional testing methods with respect to newer techniques, e.g., the Anderson-Darling method, and D'Agostino's *D*-statistic method. By means of six independent/physical cases taken from pertinent textbook literature, Chapter 3 corroborates the claim that inferences drawn from tests of normality may well depend on the testing method employed by the analyst. The findings underline the importance of caution in choosing testing methods.

In Chapter 4 the inverse problems of final observation for the system of Maxwell equations in the quasi-stationary magnetic approximation are considered. Possible applications of algorithms of the dual regularization and the iterative dual regularization for their solving are studied.

The first part of Chapter 4 is devoted to research from a single point of view of various formulations of initial-boundary value problems for Maxwell's equations in the quasi-stationary magnetic approximation, including problems for magnetic and electric fields and problems in terms of vector magnetic and scalar electric potentials under modified Coulomb and Lorenz gauges. Issues concerning to the well-posedness of the problems are studied under general conditions on the coefficients, that cover a broad class of inhomogeneous media. The relationship between solutions of problems in various formulations is considered. The stabilization of solutions as $t \to \infty$ is investigated. The results of the work based on obtained by authors estimates for vector fields scalar productions.

In the second part of Chapter 4 the problems of recovering sources and initial data from the final magnetic field configuration given with a certain error are considered. These problems are formulated as the inverse problems of final observation for the parabolic differential equation, described the magnetic field intensity or the vector magnetic potential. The considered inverse problems reduce to equivalent problems of conditional minimization in a Hilbert space with an operator equality constraint. Based on the results of the first part of the chapter the authors justify the possibility of applying algorithms of dual regularization and iterative dual regularization for designing algorithms for solving the formulated problems which stable against errors in initial data and in coefficients of Maxell's equations. As a result, in conclusion Chapter 4 different versions of the stable sequential or, in other words, regularized Lagrange principles in the considered inverse problems of

final observation for Maxwell equations in quasi-stationary magnetic approximation are formulated.

As shown in Chapter 5, the problem of nonlinear systems of first-order ordinary differential equations (ODEs in short) admitting a nonlinear superposition principle is analyzed from the perspective of the reduction of linear representations of Lie algebras by means of invariant functions of the generators. This allows to construct genuinely nonlinear realizations of Lie algebras as a Vessiot-Guldberg-Lie algebra of an appropriate system of first-order ODEs. The method is applied systematically to the case of real five-dimensional Lie algebras, a class for which the classification of equivalence classes of realizations by vector fields is currently an open problem. Other relevant types of Lie algebras admitting low-dimensional representations with invariant functions, such as semidirect sums of simple and solvable Lie algebras, are also considered.

Chapter 6 explains that one of the big challenges in dependability and reliability engineering is to deal with uncertainty. Usually, experts are asked about event's occurrences of specific events in terms of probability. It is often easier and reliable for the expert to give approximate response, such as the probability is between 0.7 and 0.9, rather than, say exactly 0.85. The question then arises, how the authors can model a probability if it is given as an interval. That is, how to assess the probability of an event's occurrence if it depends on some other events, where the probabilities of the occurrence of these other events is given as intervals.

Indeed, there are always deviations between the real world and its representation in models. Probability distribution is usually used to quantify the natural variability of random phenomena. However, when the uncertainty arises from incompleteness or imprecision of knowledge and data, probability is no longer appropriate to quantify it. This kind of uncertainty is called epistemic uncertainty. Several uncertainty theories for epistemic uncertainty quantification were presented, including Bayesian theory, imprecise probability theory, possibility theory, belief functions theory, etc.

Chapter 6 provided the necessary background for the use of precise and imprecise probability theory in the dependability and reliability fields. Novel results on the application of these uncertainty theories were developed in response to the issues posed by fundamental dependability problems. The presented results demonstrate that imprecise theories have clearly some strong advantages in many cases. The authors are convinced that application of these theories in reliability field is mature enough to be considered as an alternative to well-established classical probability theory.

As explained in Chapter 7, a vertex in a graph G is said to be a groupie if its degree is not less than the average degree of its neighbors. Various properties have been obtained concerning groupies in deterministic graph theory since they appeared for the first time in 1990s. Random graph is a well-established, fascinating topic in probabilistic combinatorics and theoretical computer science, which helps us understand the structure and development of complex networks in the information age. The studies of groupies in the setting of random graphs started only a few years ago. Chapter 7 will give a brief overview of recent results on groupies in varied random graph models including Erdös-Rényi random graphs, random bipartite graphs, as well as multipartite or stochastic block random graphs. Potential research directions and interesting open problems are examined.

CONTENTS

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Chapter 1

STATISTICAL DISCOURSE ANALYSIS: AN ALTERNATIVE TO SEQUENTIAL ANALYSIS FOR MODELING ACTIONS BY INDIVIDUALS WITHIN GROUPS

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Abstract

As sequential analysis models how recent event affect current events as transitions between different states, it can only model relative small numbers of states before facing combinatorial explosion of possible sequences of states. Statistical discourse analysis (SDA) overcomes this problem by analyzing attributes of actions/behaviors rather than states. Thus, SDA can model (a) effects of previous actions and sequences on target actions, (b) pivotal actions that radically change subsequent processes, and (c) influences at various levels (action, time period, individual, group, etc.). Moreover, SDA addresses the following additional issues involving data (unit of analysis, coding, inter-rater reliability, missing data, parallel conversations, breakpoints, time periods, statistical power), dependent variables (discrete variables, infrequency bias, nested data, multiple dependent variables), and explanatory variables (variables at earlier turns, cross-level interactions, indirect multilevel mediation, serial correlation, false positives, odds ratios, and robustness). To illustrate SDA, an example analysis shows how social metacognitive actions (e.g., agree, rudely disagree) are linked to the likelihoods of correct, new ideas (micro-creativity) and

justifications, based on 3,104 turns of talk by 80 students in 20 tetrads solving an algebra problem.

Keywords: dynamic group processes, hierarchical linear modeling, multilevel modeling, sequential analysis, time-series analysis

Statistical Discourse Analysis: An Alternative to Sequential Analysis for Modeling Actions by Individuals within Groups

Researchers are often interested in phenomena that involve sequences. When analyzing a series of sequential events (or time-series data), they often model how each event is affected by recent events (Bakeman & Quera, 1995). As sequential analysis models how recent event affect current events as transitions between different states, it can only model relative small numbers of states before facing combinatorial explosion of possible sequences of states (Chiu & Khoo, 2005). *Statistical discourse analysis* (SDA) overcomes this problem by focusing on attributes of actions/behaviors rather than states.

Statistical analyses of sequences must address several difficulties, including: (a) statistically identify pivotal actions, (b) statistically identify distinct time periods, (c) flexibly model the recent micro-time context, (d) model multiple dependent variables, or (e) test complex models with explanatory variables at multiple levels. Although many scholars recognize that some pivotal actions (e.g., an insult or a comprehensive summary) have far-reaching consequences and that people's interactions can differ across time (e.g., Leenders et al., 2016), statistically identifying these pivotal actions that divide time-series data into distinct time periods remains a challenge. Furthermore, research on interaction dynamics in groups should account for the recent micro-time context surrounding an action, which includes recent individual actions (e.g., a new idea two turns of talk ago) and sequences (e.g., three consecutive criticisms) that often requires flexible modeling. Moreover, researchers are often interested in accounting for multiple processes during group interactions (e.g., new ideas and justifications), which require models of multiple dependent variables. Lastly, explanatory variables at multiple levels (organization, group, person, time period, utterance) might be related to a focal process. Statistical discourse analysis (SDA) addresses these issues (Chiu, 2008). (Past approaches include conditional probabilities, sequential analysis, nonlinear dynamic models, pattern analysis and relational