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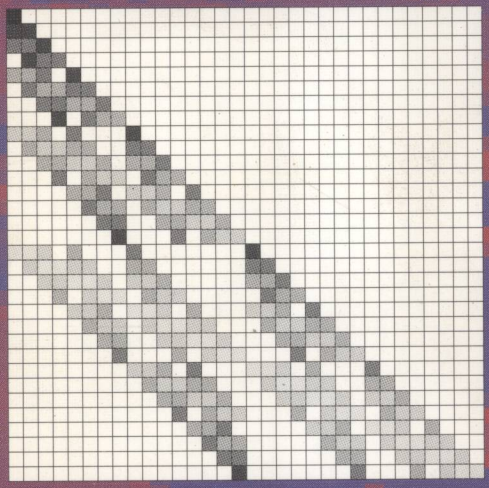
# General Theory of Information Transfer and Combinatorics



Springer

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# General Theory of Information Transfer and Combinatorics


Springer

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## Editorial Board

# Preface

The Center for Interdisciplinary Research (ZiF) of the University of Bielefeld hosted a research group under the title "General Theory of Information Transfer and Combinatorics," abbreviated as GTIT-C, from October 1, 2001 to September 30, 2004. As head of the research group the editor shaped the group's scientific directions and its personal composition.

He followed ideas, problems and results which had occupied him during the past decade and which seem to extend the frontiers of information theory in several directions. The main contributions concern information transfer by channels. There are also new questions and some answers in new models of source coding. While many of the investigations are in an explorative state, there are also hard cores of mathematical theories. In particular, a unified theory of information transfer was presented, which naturally incorporates Shannon's Theory of Information Transmission and the Theory of Identification in the presence of noise as extremal cases. It provides several novel coding theorems. On the source coding side the concept of identification entropy is introduced. Finally, beyond information theory new concepts of solutions for probabilistic algorithms arose.

In addition to this book there will be a special issue of *Discrete Applied Mathematics* "General Theory of Information Transfer and Combinatorics" in three parts, which covers primarily work with a stronger emphasis on the second component, combinatorics. It begins with an updated version of "General Theory of Information Transfer" in order to make the theory known to a broader audience and continues with other new directions such as bioinformatics, search, sorting and ordering, cryptology and number theory, and networks with many new suggestions for connections.

It includes in a special volume works and abstracts of lectures devoted to the great Levon Khachatrian at the memorial held for him during the Opening Conference, November 4-9, 2002.

In a preparatory year, October 1, 2001 – September 30, 2002, guided by the general concepts and ideas indicated and described in greater detail in the present introduction, researchers and research institutions were approached worldwide in order to find out which possible participants might be and which more concrete projects could be realized in the main research year, October 1, 2002 to August 31, 2003.

Central events in this phase were two weekly preparatory meetings in February: General Theory of Information Transfer, abbreviated as GTIT, and Information in Natural Sciences, Social Sciences, Humanities and Engineering. Abstracts of the lectures can be found at
`http://www.math.uni-bielefeld.de/ahlswede/zif`.

The main goals were to test the applicability of the GTIT, particularly identification, and to strive for new information phenomena in the sciences, which

can be modelled mathematically. Readers are strongly advised to read the Introduction for guidance.

Our special thanks go to the members of the administration of the "Zentrum für interdisziplinäre Forschung" (ZiF) in Bielefeld for a very pleasant cooperation and, in particular, to Gertrude Lübbe-Wolf, who as acting director authorized and generously supported this project, and to Ibke Wachsmuth, who continued her policy. Dr. Roggenhöfer, who was always responsive to new ideas and wishes is also thanked for his assistance.

June 2006 Rudolf Ahlswede

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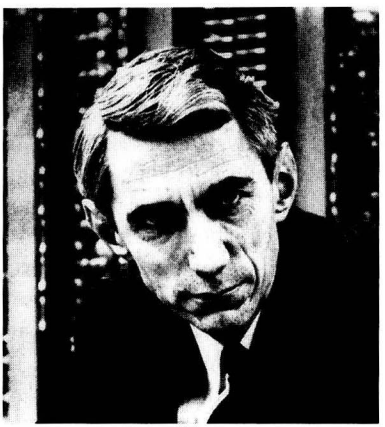
More than restoring
strings of symbols transmitted
means transfer today

Rudolf Ahlswede

# Introduction



The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point.

Claude E. Shannon

**What is information?**

$\boxed{Cn \text{ bits}}$ in Shannon's fundamental theorem

or

$\boxed{\log Cn \text{ bits}}$ in our Theory of Identification ?

Among the directions of research in GTIT-C, which could be established, we present in Chapters I-IX contributions of participants, which took shape in written form. The papers were thoroughly refereed. For the ease of reference they are numbered and in addition labelled by the letter B, which hints at this book.

There are other lists of publications we refer to. They are labelled by A,C, and D, where

R. Ahlswede et al. (Eds.): Information Transfer and Combinatorics, LNCS 4123, pp. 1–44, 2006.

A indicates the editors present list of publications at the end of the book

C is used for papers mentioned in the preface, in particular in these comments

D gives the titles of the papers in the related Special Issue in Discrete Applied Mathematics (3 volumes)

It must be emphasized that there were several lectures and discussions with many ideas, which influenced work, which appears elsewhere. Also, several subjects with noticeable informational components are not ready for a theoretical and in particular mathematical frame.

For instance in **Bio-Chemistry** there are many advanced experiments concerning "signalling", where some kind of intensity is measured, but essentially nothing is known about transmission rates. Still we learnt a lot from several very stimulating lectures of Raimund Apfelbach about the "state of the art". Moreover, we are particularly thankful for his engagement in helping to shape a group for **Animal Communication** beyond his own work related to smelling.

In many lectures, especially also by young German emigrants to Great Britain, we were excited by an extremely rich and very active field in recent years. There are fascinating ways of encoding information (well-known a long time for bees and more recently for ants etc). Mathematical models are more in a beginning state. Our hope that in the kingdom of animals nature has chosen other forms of information transfer, like in identification, could not be verified. It seems that knowledge of these forms is a necessary prerequisite for setting up suitable experiments.

At least we know where one may start. Several abstracts from the April 2004 Final Meeting the reader can find at
`http://www.math.uni-bielefeld.de/ahlswede/zif`. We also mention two instructive books [C10], [C49]. With advanced technology many new experiments have become possible here.

Similar observations can be made about **Psychology**. However, there have been signals encouraging careful reading, intuitive perception or enjoyment of G. Dueck's book [C25] with its classification of people into "right", "true" or "natural" and corresponding different key roles identification seems to play for them.

A last statement in this context we want to make about **Philosophical Ideas** concerning *information concepts and measures*, in particular about K.F. von Weizsäcker's monumental *attempt* [C100] to base all of Physics on an information concept – central even for time and space. We found that the newly discovered concept of *identification entropy* [B33], which has an unquestionable operational meaning, *is not covered by that approach and therefore challenges it!* Philosophers are called again to share a world with mathematicians and vice versa.

We hope to have made understandable why we did not receive contributions to Bio-Chemistry, Animal Communication, Psychology and Philosophy for this book.

There is, however, for instance a contribution to **Language Evolution** [B46], in which a **Conjecture of Nowak**, the man who has been running a five year