

A tour with Constructive Real Numbers

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Abstract. The aim of this work is to characterize constructive real numbers through a minimal axiomatization. We introduce, discuss and justify 16 constructive axioms. Then we address their expressivity considering the alternative axiomatizations.

1 Overview of the work

Real numbers are classically defined as a complete ordered field, but this is not the case in a constructive logic setting: actually the totality of order is not a constructive property.

This work tries to understand (again) constructive real numbers. Our main contribution is a new system of axioms, synthesized with the aim of being minimal, i.e. of assuming the least number of primitive notions and properties. Such a system is consistent with respect to reference models we have in mind — (equivalence classes of) Cauchy sequences [TvD88] and co-inductive streams of digits [CDG00] — and will be compared to other proposals in the literature [Br99, GPWZ00]. The expressive power of the axioms will be addressed in order to guarantee that a sufficient part of the constructive analysis can be derived from them.

We define constructive real numbers through sixteen axioms organized in four groups: arithmetic operations, ordering, Archimedes' postulate and completeness. Our axiomatization uses only three basic concepts: addition (+), multiplication (\times) and strict order (<).

In most of the constructive approaches to analysis [Be67, Be85, Wei00] real numbers are defined as a quotient of a set of representations (e.g. equivalence classes of Cauchy sequences, digit expansions, etc.). It follows that also in an axiomatic approach it is necessary to see the reals as a set provided with an equivalence relation. In our proposal, this equivalence relation (\sim) is not a primitive notion, but it is derived together with its fundamental properties through the strict order relation. We define the equivalence by $(x \sim y) \triangleq \neg((x < y) \vee (y < x))$; the fact that the equivalence relation is preserved by the arithmetic operations follows from the following axioms, which reverse the usual perspective:

$$\begin{aligned}(x + z < y + z) &\rightarrow (x < y) \\ (x \times z < y \times z) &\rightarrow (x < y) \vee ((y < x) \wedge (z < 0))\end{aligned}$$

Constructive Real Numbers Constructive

Arend Heyting



Constructive Real Numbers Constructive:

Constructive Real Numbers and Constructive Function Spaces Nikolai Aleksandrovich Shanin, 1968 This book is devoted to certain problems of constructive mathematical analysis I The basic sections are Chapters II and III which are devoted to the foundations of the theory of constructive function spaces Information from the theory of constructive real numbers needed in these chapters is presented in the first chapter The first chapter also contains other material in it the logicomathematical symbolism which we shall use is described and some problems of constructive mathematical logic are considered Constructive Real Numbers and Function Spaces Sanin. N.A, 2000-08-01 *Mathematics Of Harmony As A New Interdisciplinary Direction And "Golden" Paradigm Of Modern Science - Volume 2: Algorithmic Measurement Theory, Fibonacci And Golden Arithmetic's And Ternary Mirror-symmetrical Arithmetic* Alexey Stakhov, 2020-09-03 Volume II is the second part of the 3 volume book Mathematics of Harmony as a New Interdisciplinary Direction and Golden Paradigm of Modern Science Mathematics of Harmony rises in its origin to the harmonic ideas of Pythagoras Plato and Euclid this 3 volume book aims to promote more deep understanding of ancient conception of the Universe Harmony the main conception of ancient Greek science and implementation of this conception to modern science and education This 3 volume book is a result of the authors research in the field of Fibonacci numbers and the Golden Section and their applications It provides a broad introduction to the fascinating and beautiful subject of the Mathematics of Harmony a new interdisciplinary direction of modern science This direction has many unexpected applications in contemporary mathematics a new approach to a history of mathematics the generalized Fibonacci numbers and the generalized golden proportions the generalized Binet's formulas theoretical physics new hyperbolic models of Nature and computer science algorithmic measurement theory number systems with irrational bases Fibonacci computers ternary mirror symmetrical arithmetic The books are intended for a wide audience including mathematics teachers of high schools students of colleges and universities and scientists in the field of mathematics theoretical physics and computer science The book may be used as an advanced textbook by graduate students and even ambitious undergraduates in mathematics and computer science Encyclopaedia of Mathematics M. Hazewinkel, 2013-12-01 Constructive Real Numbers and Constructive Functions Space N.A. Sanin, 1968 Notes on Constructive Mathematics Per Martin-Löf, 1970 **Encyclopaedia of Mathematics** Michiel Hazewinkel, 2013-12-01 This ENCYCLOPAEDIA OF MATHEMATICS aims to be a reference work for all parts of mathematics It is a translation with updates and editorial comments of the Soviet Mathematical Encyclopaedia published by Soviet Encyclopaedia Publishing House in five volumes in 1977 1985 The annotated translation consists of ten volumes including a special index volume There are three kinds of articles in this ENCYCLOPAEDIA First of all there are survey type articles dealing with the various main directions in mathematics where a rather fine subdivision has been used The main requirement for these articles has been that they should give a reasonably complete up to date account of the current state of affairs in these areas and that they

should be maximally accessible On the whole these articles should be understandable to mathematics students in their first specialization years to graduates from other mathematical areas and depending on the specific subject to specialists in other domains of science engineers and teachers of mathematics These articles treat their material at a fairly general level and aim to give an idea of the kind of problems techniques and concepts involved in the area in question They also contain background and motivation rather than precise statements of precise theorems with detailed definitions and technical details on how to carry out proofs and constructions The second kind of article of medium length contains more detailed concrete problems results and techniques

Constructive Real Numbers and Constructive Function Spaces N. A. Shanin, 1968

Techniques of Constructive Analysis Douglas S. Bridges, Luminata Simona Vita, 2007-04-30 This book is an introduction to constructive mathematics with an emphasis on techniques and results obtained in the last twenty years The text covers fundamental theory of the real line and metric spaces focusing on locatedness in normed spaces and with associated results about operators and their adjoints on a Hilbert space The first appendix gathers together some basic notions about sets and orders the second gives the axioms for intuitionistic logic No background in intuitionistic logic or constructive analysis is needed in order to read the book but some familiarity with the classical theories of metric normed and Hilbert spaces is necessary

Handbook of Constructive Mathematics Douglas Bridges, Hajime Ishihara, Michael Rathjen, Helmut Schwichtenberg, 2023-05-11 Gives a complete overview of modern constructive mathematics and its applications through surveys by leading experts

Research Topics in Functional Programming D. A. Turner, 1990

Real Analysis Mark Bridger, 2011-10-14 A unique approach to analysis that lets you apply mathematics across a range of subjects This innovative text sets forth a thoroughly rigorous modern account of the theoretical underpinnings of calculus continuity differentiability and convergence Using a constructive approach every proof of every result is direct and ultimately computationally verifiable In particular existence is never established by showing that the assumption of non existence leads to a contradiction The ultimate consequence of this method is that it makes sense not just to math majors but also to students from all branches of the sciences The text begins with a construction of the real numbers beginning with the rationals using interval arithmetic This introduces readers to the reasoning and proof writing skills necessary for doing and communicating mathematics and it sets the foundation for the rest of the text which includes Early use of the Completeness Theorem to prove a helpful Inverse Function Theorem Sequences limits and series and the careful derivation of formulas and estimates for important functions Emphasis on uniform continuity and its consequences such as boundedness and the extension of uniformly continuous functions from dense subsets Construction of the Riemann integral for functions uniformly continuous on an interval and its extension to improper integrals Differentiation emphasizing the derivative as a function rather than a pointwise limit Properties of sequences and series of continuous and differentiable functions Fourier series and an introduction to more advanced ideas in functional analysis Examples throughout the text demonstrate the application of new

concepts Readers can test their own skills with problems and projects ranging in difficulty from basic to challenging This book is designed mainly for an undergraduate course and the author understands that many readers will not go on to more advanced pure mathematics He therefore emphasizes an approach to mathematical analysis that can be applied across a range of subjects in engineering and the sciences **Soviet Mathematics** ,1975 *Soviet Mathematics - Doklady* ,1985

Constructive Analysis, Types and Exact Real Numbers ,2007 **Glasnik matematičko-fizički i astronomski**
,1965 **Boundary Value Problems of Mathematical Physics and Related Aspects of Function Theory** ,1969

Logic and Foundations of Mathematics Arend Heyting,1969 **Mechanical Theorem Proving in the USSR**
Vladimir Lifschitz,1986 **Chinese Mathematics** ,1964

Constructive Real Numbers Constructive Book Review: Unveiling the Magic of Language

In an electronic era where connections and knowledge reign supreme, the enchanting power of language has become more apparent than ever. Its capability to stir emotions, provoke thought, and instigate transformation is actually remarkable. This extraordinary book, aptly titled "**Constructive Real Numbers Constructive**," written by a very acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound effect on our existence. Throughout this critique, we shall delve in to the book is central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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