4 dimensional mathematical model of the universe

A Critical Analysis of 4-Dimensional Mathematical Models of the Universe

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Abstract: This analysis critically examines the development and impact of 4-dimensional mathematical models of the universe, focusing on their role in advancing our understanding of cosmology and its current trends. We explore the limitations of existing models, the potential of incorporating higher dimensions, and the challenges in testing these complex theoretical frameworks. The analysis highlights the significant contribution of these models to current cosmological research while acknowledging the ongoing debates and unresolved questions.

1. Introduction: The Quest for a Comprehensive Model

The pursuit of a comprehensive 4-dimensional mathematical model of the universe has been a central theme in theoretical physics for over a century. Einstein's general theory of relativity, a remarkably successful 4-dimensional model incorporating spacetime, revolutionized our understanding of gravity and the large-scale structure of the universe. However, general relativity, while describing gravity extremely well on large scales, encounters inconsistencies when combined with quantum mechanics at the Planck scale. This incompatibility necessitates the search for more comprehensive models.

The current standard model of cosmology, based on general relativity and the Lambda-CDM model, provides a good description of the observable universe, incorporating dark matter and dark energy. Yet, several fundamental questions remain unanswered: the nature of dark matter and dark energy, the singularity at the Big Bang, and the ultimate fate of the universe. These unresolved issues fuel the ongoing research into refined and more encompassing 4-dimensional mathematical models of the universe.

2. Exploring the 4-Dimensional Framework: Spacetime and its Implications

The foundation of most 4-dimensional models lies in the concept of spacetime—a unified entity combining three spatial dimensions and one temporal dimension. General relativity elegantly describes the curvature of spacetime caused by mass and energy, explaining gravitational phenomena. However, this framework, while powerful, falls short in explaining phenomena at the quantum level, where gravity's effects are significant.

The four dimensions in the 4-dimensional mathematical model of the universe aren't just arbitrary coordinates. They are inextricably linked, with events defined by their location in both space and time. The curvature of spacetime, as predicted by general relativity, is crucial to understanding the dynamics of celestial bodies, the expansion of the universe, and gravitational lensing.

3. Limitations of Current 4-Dimensional Models and the Need for Extensions

Despite the successes of general relativity, several limitations hinder its ability to provide a complete description of the universe. Firstly, the singularity at the Big Bang represents a breakdown of the theory, indicating a need for a more fundamental understanding of the universe's origins. Secondly, the incorporation of quantum mechanics remains a major challenge. The quantization of gravity, a crucial step in unifying general relativity with quantum mechanics, remains elusive.

Moreover, the nature of dark matter and dark energy, which constitute a significant portion of the universe's mass-energy density, is currently unknown. Current 4-dimensional mathematical models do not fully explain these enigmatic components. Therefore, the quest for a more complete 4-dimensional mathematical model of the universe pushes physicists to explore extensions or alternatives.

4. The Allure of Higher Dimensions: Beyond Four Dimensions

String theory and other related theories propose the existence of extra spatial dimensions beyond the three we perceive. These higher-dimensional models offer potential solutions to the limitations of 4-dimensional models.

They suggest that the apparent four-dimensionality of our universe might be a manifestation of a higher-dimensional reality, with the extra dimensions curled up or compactified at scales too small to be directly observed.

Incorporating these extra dimensions could provide a framework for unifying general relativity with quantum mechanics, potentially resolving the inconsistencies at the Planck scale. Furthermore, higher-dimensional models might offer explanations for the nature of dark matter and dark energy. The exploration of higher dimensions, however, requires sophisticated mathematical tools and often involves abstract concepts that challenge our intuitive understanding of the universe.

5. Testing and Falsifiability: The Crucial Role of Observational Data

The development of a 4-dimensional mathematical model of the universe is not merely an intellectual exercise; it must be testable and falsifiable. Theoretical models, no matter how elegant, must be supported by observational evidence. Current efforts focus on devising experiments and observations to probe the predictions of these models. For example, gravitational wave astronomy offers promising avenues for testing aspects of general relativity and potentially uncovering signatures of higher dimensions or modifications to gravity.

The search for deviations from the predictions of the Lambda-CDM model, such as anomalies in the cosmic microwave background radiation or discrepancies in the large-scale structure of the universe, can provide crucial clues to refining or replacing existing models.

6. Current Trends and Future Directions in 4-Dimensional Modeling

Current trends in the development of 4-dimensional mathematical models of the universe include:

Loop Quantum Gravity: This approach attempts to quantize spacetime itself, avoiding the need for a background spacetime as in string theory.
Causal Set Theory: This model proposes a discrete structure of spacetime, potentially resolving the singularity problem.
Modified Gravity Theories: These theories modify general relativity to explain the observed acceleration of the universe's expansion without resorting to dark energy.

Future directions in this field likely involve combining different theoretical approaches, incorporating advanced computational techniques, and exploiting new observational data from telescopes and gravitational wave detectors. The development of more sophisticated numerical simulations is also crucial in testing the predictions of these complex models.

7. Conclusion

The quest for a 4-dimensional mathematical model of the universe remains a central challenge in theoretical physics. While existing models like general relativity have achieved remarkable success, limitations exist that necessitate the exploration of more comprehensive frameworks. The incorporation of higher dimensions, the unification of general relativity with quantum mechanics, and the explanation of dark matter and dark energy are among the key objectives driving ongoing research. The rigorous testing of these models through observational data is critical for advancing our understanding of the universe's structure and evolution. The future of this field will undoubtedly involve a blend of theoretical innovation and experimental verification, pushing the boundaries of our knowledge of the cosmos.

FAQs

1. What is the significance of the fourth dimension in cosmological models? The fourth dimension, time, is crucial as it integrates with the three spatial dimensions to form spacetime, the fabric on which the universe unfolds. Its incorporation is essential for describing gravity and the evolution of the universe.

1. How do 4-dimensional models differ from higher-dimensional models? 4-dimensional models focus solely on the four dimensions we directly experience (three spatial and one temporal). Higher-dimensional models, such as string theory, postulate additional spatial dimensions, often compactified at subatomic scales, influencing our perceived 4-dimensional reality.

1. What are the limitations of using a 4-dimensional model to describe the entire universe? 4-dimensional models, while successful on large scales, break down at the singularity of the Big Bang and fail to incorporate quantum effects at the Planck scale. They also struggle to explain dark matter and dark energy.

1. What are some examples of 4-dimensional mathematical models used in cosmology? General relativity is the most prominent example. Other models like the Lambda-CDM model build upon it to describe the large-scale structure of the universe.

1. How can we test the validity of a 4-dimensional model of the universe? Testing involves comparing the model's predictions with observational data from various sources, including the cosmic microwave background, gravitational waves, large-scale structure surveys, and astronomical observations.

1. What are the potential implications of discovering extra dimensions? Discovering extra dimensions would revolutionize our understanding of physics and cosmology, potentially unifying gravity with other fundamental forces and offering explanations for dark matter and dark energy.

1. What role do computer simulations play in the study of 4-dimensional models? Simulations are essential for testing the predictions of complex models, visualizing their behavior, and exploring different scenarios. They allow researchers to study the evolution of the universe under various conditions.

1. Are there any ethical considerations related to advanced cosmological modeling? While the direct ethical implications are minimal, the potential for misuse of sophisticated technologies developed for cosmological modeling, such as advanced computing, requires careful ethical consideration.

1. What are the future prospects for research into 4-dimensional models of the universe? Future research will likely focus on unifying general relativity with quantum mechanics, explaining dark matter and dark energy, and developing more accurate and testable models. New observational data will play a critical role.

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4 dimensional mathematical model of the universe: *Mathematical Modeling Through Topological Surgery and Applications* Stathis Antoniou, 2018-08-23 Topological surgery is a mathematical technique used for creating new manifolds out of known ones. In this book the authors observe that it also occurs in natural phenomena of all scales: 1-dimensional surgery happens during DNA recombination and when cosmic magnetic lines reconnect; 2-dimensional surgery happens during tornado formation and cell mitosis; and they conjecture that 3-dimensional surgery happens during the formation of black holes from cosmic strings, offering an explanation for the existence of a black hole's singularity. Inspired by such phenomena, the authors present a new topological model that extends the formal definition to a continuous process caused by local forces. Lastly, they describe an intrinsic connection between topological surgery and a chaotic dynamical system exhibiting a "hole drilling" behavior. The authors' model indicates where to look for the forces causing surgery and what deformations should be observed in the local submanifolds involved. These predictions are significant for the study of phenomena exhibiting surgery and they also open new research directions. This novel study enables readers to gain a better understanding of the topology and dynamics of various natural phenomena, as well as topological surgery itself and serves as a basis for many more insightful observations and new physical implications.

4 dimensional mathematical model of the universe: *The Expanding Worlds of General Relativity* Hubert Goenner, Jürgen Renn, Jim Ritter, Tilman Sauer, 1998-12-01 The past decade has seen a considerable surge of interest in historical and philo sophical studies of gravitation and relativity, due not only to the tremendous amount of world-wide research in general relativity and its theoretical and observational consequences, but also to an increasing awareness that a collaboration between working scientists, historians and philosophers of science is, in this field, partic ularly promising for all participants. The expanding activity in this field is well documented by recent volumes in this Einstein Studies series on the History of General Relativity as well as by a series of international conferences on this topic at Osgood Hill (1986), Luminy (1988), and Pittsburgh (1991). The fourth of these conferences, hosted by the Max Planck Institute for the History of Science, was held in Berlin from 31 July to 3 August 1995, with a record attendance of some 80 historians and philosophers of science, physicists, mathematicians, and as tronomers. Based on presentations at the Berlin conference, this volume provides an overview of the present state of research in this field, documenting not only the increasing scope of recent investigations in the history of relativity and gravitation but also the emergence of several key issues that will probably remain at the focus of debate in the near future. RELATIVITY IN THE MAKING The papers of this section deal with the origins and genesis of relativity theory.

4 dimensional mathematical model of the universe: Extra Dimensions in Space and Time Itzhak Bars, John Terning, 2009-12-04 In physics, the idea of extra spatial dimensions originates from Nordstöm's 5-dimensional vector theory in 1914, followed by Kaluza-Klein theory in 1921, in an effort to unify general relativity and electromagnetism in a 5 dimensional space-time (4 dimensions for space and 1 for time). Kaluza–Klein theory didn't generate enough interest with physicist for the next five decades, due to its problems with inconsistencies. With the advent of supergravity theory (the theory that unifies general relativity and supersymmetry theories) in late 1970's and eventually, string theories (1980s) and M-theory (1990s), the dimensions of space-time increased to 11 (10-space and 1-time dimension). There are two main features in this book that differentiates it from other books written about extra dimensions: The first feature is the coverage of extra dimensions in time (Two Time physics), which has not been covered in earlier books about extra dimensions. All other books mainly cover extra spatial dimensions. The second feature deals with level of presentation. The material is presented in a non-technical language followed by additional sections (in the form of appendices or footnotes) that explain the basic equations and formulas in the theories. This feature is very attractive to readers who want to find out more about the theories involved beyond the basic description for a layperson. The text is designed for scientifically literate non-specialists who want to know the latest discoveries in theoretical physics in a non-technical language. Readers with basic undergraduate background in modern physics and quantum mechanics can easily understand the technical sections. Part I starts with an overview of the Standard Model of particles and forces, notions of Einstein’s special and general relativity, and the overall view of the universe from the Big Bang to the present epoch, and covers Two-Time physics. 2T-physics has worked correctly at all scales of physics, both macroscopic and microscopic, for which there is experimental data so far. In addition to revealing hidden information even in familiar everyday physics, it also makes testable predictions in lesser known physics regimes that could be analyzed at the energy scales of the Large Hadron Collider at CERN or in cosmological observations. Part II of the book is focused on extra dimensions of space. It covers the following topics: The Popular View of Extra Dimensions, Einstein and the Fourth Dimension, Traditional Extra Dimensions, Einstein's Gravity, The Theory Formerly Known as String, Warped Extra Dimensions, and How Do We Look For Extra Dimensions?

4 dimensional mathematical model of the universe: Mathematical Models In Science Olav Arnfinn Laudal, 2021-06-16 Mathematical Models in Science treats General Relativity and Quantum Mechanics in a non-commutative Algebraic Geometric framework.Based on ideas first published in Geometry of Time-Spaces: Non-commutative Algebraic Geometry Applied to Quantum Theory (World Scientific, 2011), Olav Arnfinn Laudal proposes a Toy Model as a Theory of Everything, starting with the notion of the Big Bang in Cosmology, modeled as the non-commutative deformation of a thick point. From this point, the author shows how to extract reasonable models for both General Relativity and Quantum Theory. This book concludes that the universe turns out to be the 6-dimensional Hilbert scheme of pairs of points in affine 3-space. With this in place, one may develop within the model much of the physics known to the reader. In particular, this theory is applicable to the concept of Dark Matter and its effects on our visual universe.Hence, Mathematical Models in Science proves the dependency of deformation theory in Mathematical Physics and summarizes the development of physical applications of pure mathematics developed in the twentieth century.

4 dimensional mathematical model of the universe: *Unified Field Theory* Murat Ukray, 2015-04-12 UKRAY - UNIFIED FIELD THEORY - - A New Unification Theory on Electromagnetic Gravitation- PREFACE “This study which aims to prove that all forces and laws of physics exist in a single unified structure at the Starting and Ending moment of the Universe analyzes all laws of physics within the framework of a unified structure from Newton Mechanics to Quantum Theory, Einstein Relativity to modern 11-dimensional Super string theory. The study may also be considered as a MODERN ERA PRINCIPIA since it was started to be written in about 300 years (early 2007) after the publication of the great study of Newton named PRINCIPIA (1703-1707) on the topic of gravity theories. The volume includes SEVEN CHAPTERS in the form of SEVEN different articles which follow each other and make clear the subject when they are read consecutively. In addition, FOUR additional chapters in the form of APPENDIXES in nature of FUNDAMENTALS OF MATHEMATICS were also included at the end of the volume for readers who have a less degree of technical knowledge about the topic... THIS THEORY, GETS THESE QUESTIONS INTO; - A CHANGE into Gravitational field and field equations, STATIC AND UNIVERSAL GRAVITATIONAL CONSTANTS, - THE DYNAMICS OF Gravitational field with Combining the Electromagnetics Theory. - THE VELOCITY OF LIGHT COULD BE EXCEEDED? THIS THEORY WAS PREPARED AS A CONSEQUENCE OF APPROXIMATELY 16 YEARS STUDY, - WHOLE 666 PAGE - INCLUDES ABOUT

100 THEOREMS, - AND 1000 ILLUSTRATED DRAWINGS, - ASSERTS THE NEW PHYSICS OF THE UNIVERSE. AND MUCH MORE... This oriented me to a series of researches to study and create this theory for years and then directed me to create a unified electromagnetic gravity theory composed of SEVEN ARTICLES in total I will submit here in order and step by step. Even though the theory includes a deductive mathematical approach, tensor calculation and geometric modellings, I will give solutions of Einstein-Maxwell Equations with a different mathematical 4x4 Pauli-Dirac Spinors and Tensor calculation construction in direction of closed extra dimension of the space (5 Dimension Effect) What Does the Theory Tell? {Short Abstract and Philosophy of the Theory} The THEORY summarizes the general and simple mathematical description of the universe in the form of general conclusion items and forecasts the followings; Basic Projections of the Theory? - NEW MODEL OF AN ATOM, - NEW MODEL OF THE UNIVERSE, - CHANGE IN GALILEO Inertia Principle, - A Fundamental Change in the Structure of MAXWELL's EQUATIONS, AN ADDITIONAL TERMS AND ADDITIONS, - A CHANGE IN POYNTING ENERGY THEORY, - A NEW ATOMIC MODEL, - A NEW UNIVERSE MODEL, - CHANGE IN GALILEO'S PRINCIPLE OF INERTIA, - A FUNDEMENTAL CHANGE AND AN ADDITIONAL TERM IN THE STRUCTURE IF MAXWELL EQUATIONS, - A CHANGE IN STATIC FIELD EQUATIONS OF THE GRAVITY FIELD AND IN THE UNIVERSAL GRAVITY CONSTANT. - CHANGE IN POYNTING ENERGY THEOREM, - HOW CAN THE VELOCITY OF LIGHT BE EXCEEDED?

4 dimensional mathematical model of the universe: Minkowski Space Paul F. Kisak, 2016-05-25 In mathematical physics, Minkowski space or Minkowski spacetime is a combination of Euclidean space and time into a four-dimensional manifold where the spacetime interval between any two events is independent of the inertial frame of reference in which they are recorded. Although initially developed by mathematician Hermann Minkowski for Maxwell's equations of electromagnetism, the mathematical structure of Minkowski spacetime was shown to be an immediate consequence of the postulates of special relativity. Minkowski space is closely associated with Einstein's theory of special relativity, and is the most common mathematical structure on which special relativity is formulated. While the individual components in Euclidean space and time will often differ due to length contraction and time dilation, in Minkowski spacetime, all frames of reference will agree on the total distance in spacetime between events. Because it treats time differently than the three spatial dimensions, Minkowski space differs from four-dimensional Euclidean space. In Euclidean space, the isometry group (the maps preserving the regular inner product) is the Euclidean group. The analogous isometry group for Minkowski space, preserving intervals of spacetime equipped with the associated non-positive definite bilinear form (here called the Minkowski inner product,) is the Poincare group. The Minkowski inner product is defined as to yield the spacetime interval between two events when given their coordinate difference vector as argument.

4 dimensional mathematical model of the universe: Dichronauts Greg Egan, 2017-07-11 Seth is a surveyor, along with his friend Theo, a leech-like creature running through his skull who tells Seth what lies to his left and right. Theo, in turn, relies on Seth for mobility, and for ordinary vision looking forwards and backwards. Like everyone else in their world, they are symbionts, depending on each other to survive. In the universe containing Seth's world, light cannot travel in all directions: there is a “dark cone” to the north and south. Seth can only face to the east (or the west, if he tips his head backwards). If he starts to turn to the north or south, his body stretches out across the landscape, and to rotate as far as north-north-east is every bit as impossible as accelerating to the speed of light. Every living thing in Seth’s world is in a state of perpetual migration as they follow the sun’s shifting orbit and the narrow habitable zone it creates. Cities are being constantly disassembled at one edge and rebuilt at the other, with surveyors mapping safe routes ahead. But when Seth and Theo join an expedition to the edge of the habitable zone, they discover a terrifying threat: a fissure in the surface of the world, so deep and wide that no one can perceive its limits. As the habitable zone continues to move, the migration will soon be blocked by this unbridgeable void, and the expedition has only one option to save its city from annihilation: descend into the unknown.

4 dimensional mathematical model of the universe: *The Cognitive-Theoretic Model of the Universe: A New Kind of Reality Theory* Christopher Michael Langan, 2002-06-01 Paperback version of the 2002 paper published in the journal Progress in Information, Complexity, and Design (PCID). ABSTRACT Inasmuch as science is observational or perceptual in nature, the goal of providing a scientific model and mechanism for the evolution of complex systems ultimately requires a supporting theory of reality of which perception itself is the model (or theory-to-universe mapping). Where information is the abstract currency of perception, such a theory must incorporate the theory of information while extending the information concept to incorporate reflexive self-processing in order to achieve an intrinsic (self-contained) description of reality. This extension is associated with a limiting formulation of model theory identifying mental and physical reality, resulting in a reflexively self-generating, self-modeling theory of reality identical to its universe on the syntactic level. By the nature of its derivation, this theory, the Cognitive Theoretic Model of the Universe or CTMU, can be regarded as a supertautological reality-theoretic extension of logic. Uniting the theory of reality with an advanced form of computational language theory, the CTMU describes reality as a Self Configuring Self-Processing Language or SCSPL, a reflexive intrinsic language characterized not only by self-reference and recursive self-definition, but full self-configuration and self-execution (reflexive read-write functionality). SCSPL reality embodies a dual-aspect monism consisting of infocognition, self-transducing information residing in self-recognizing SCSPL elements called syntactic operators. The CTMU identifies itself with the structure of these operators and thus with the distributive syntax of its self-modeling SCSPL universe, including the reflexive grammar by which the universe refines itself from unbound telesis or UBT, a primordial realm of infocognitive potential free of informational constraint. Under the guidance of a limiting (intrinsic) form of anthropic principle called the Telic Principle, SCSPL evolves by telic recursion, jointly configuring syntax and state while maximizing a generalized self-selection parameter and adjusting on the fly to freely-changing internal conditions. SCSPL relates space, time and object by means of conspansive duality and conspansion, an SCSPL-grammatical process featuring an alternation between dual phases of existence associated with design and actualization and related to the familiar wave-particle duality of quantum mechanics. By distributing the design phase of reality over the actualization phase, conspansive spacetime also provides a distributed mechanism for Intelligent Design, adjoining to the restrictive principle of natural selection a basic means of generating information and complexity. Addressing physical evolution on not only the biological but cosmic level, the CTMU addresses the most evident deficiencies and paradoxes associated with conventional discrete and continuum models of reality, including temporal directionality and accelerating cosmic expansion, while preserving virtually all of the major benefits of current scientific and mathematical paradigms.

4 dimensional mathematical model of the universe: An Introduction to Mathematical Cosmology Jamal N. Islam, 2002 An introductory textbook on mathematical cosmology for beginning graduate students.

4 dimensional mathematical model of the universe: Instantaneous Action at a Distance in Modern Physics Andrew E. Chubykalo, Pope, Viv, Roman Smirnov-Rueda, 1999 The so-far unanswered question of whether the movements of distance-separated objects are correlated in the way quantum physics requires or whether, according to Einstein, they can influence one another only by mechanical agencies travelling between them at speeds limited to that of light. It is to that still unanswered question that this present compilation of papers is addressed. The editorial approach is unusual in that in order to break the current conceptual deadlock and to encourage true innovation they have solicited inputs which are multidisciplinary. This open-ended venture is therefore perhaps more in line with what was once called Natural Philosophy than with what is currently known as 'Physics'. This is something of a departure for those who say that Physics no longer has anything to do with Philosophy. For there are physicists who believe that their predecessors have accomplished all the really important conceptual work on interpreting natural phenomena, so that there is no longer any call for radical revision in that direction. This leads to a constricted form of the discipline in which the purpose of all observation and experimentation is seen as simply to collect more and more information and fit it to conceptions which are traditionally 'cut and dried'. The emphasis is thus on presenting informed and carefully considered descriptions of natural phenomena, economizing as far as possible on interpretations in terms of entities which turn out to be no more than speculative.

4 dimensional mathematical model of the universe: Death's End Cixin Liu, 2016-09-20 Mutually assured destruction has led to decades of peace between humanity and the Trisolarans, but a new force is awakening and this delicate balance can no longer hold... Half a century after the Doomsday Battle, the uneasy balance of Dark Forest Deterrence keeps the Trisolaran invaders at bay. Earth enjoys unprecedented prosperity due to the infusion of Trisolaran knowledge. With human science advancing daily and the Trisolarans adopting Earth culture, it seems that the two civilizations will soon be able to co-exist peacefully as equals without the terrible threat of mutually assured annihilation. But the peace has also made humanity complacent. Cheng Xin, an aerospace engineer from the early twenty-first century, awakens from hibernation in this new age. She brings with her knowledge of a long-forgotten program dating from the beginning of the Trisolar Crisis, and her very presence may upset the delicate balance between two worlds. Will humanity reach for the stars or die in its cradle? Death's End is the New York Times bestselling conclusion to Cixin Liu's tour-de-force series that began with The Three-Body Problem. The War of the Worlds for the twenty-first century . . . Packed with a sense of wonder. --The Wall Street Journal A meditation on technology, progress, morality, extinction, and knowledge that doubles as a cosmos- in-the-balance thriller. --NPR The Remembrance of Earth's Past Trilogy The Three-Body Problem The Dark Forest Death's End Other Books Ball Lightning (forthcoming)

4 dimensional mathematical model of the universe: Experiments in Four Dimensions David L. Heiserman, 1983

4 dimensional mathematical model of the universe: Advances in Intelligent Systems and Computing Natalya Shakhovska, 2016-09-12 The book reports on new theories and applications in the field of intelligent systems and computing. It covers computational and artificial intelligence methods, as well as advances in computer vision, current issue in big data and cloud computing, computation linguistics, cyber-physical systems as well as topics in intelligent information management. Written by active researchers, the different chapters are based on contributions presented at the workshop in intelligent systems and computing (ISC), held during CSIT 2016, September 6-9, and jointly organized by the Lviv Polytechnic National University, Ukraine, the Kharkiv National University of Radio Electronics, Ukraine, and the Technical University of Lodz, Poland, under patronage of Ministry of Education and Science of Ukraine. All in all, the book provides academics and professionals with extensive information and a timely snapshot of the field of intelligent systems, and it is expected to foster new discussions and collaborations among different groups.

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