Book of Abstracts

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Theme:
Advancing Sustainable Development Goals (SDGs) through Mathematics, Statistics and AI

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ABSTRACTS

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How did we get here? A brief history of AI (and its ups and downs)

Alfredo Terzoli[a]
[a] Full Professor of Computer Science at University of Zululand and an Emeritus Professor in the Science Faculty of Rhodes University, in South Africa.

Abstract

While conversations about Artificial Intelligence (AI) within the large public are recent and mostly due to the breakthroughs in Large Language Models (LLMs), the history of AI is a long one: almost as long as the history of digital computers, in fact. An understanding of its history is important to situate appropriately specific technological achievements, such as the ones relating to LLMs. This contextualization does allow us to judge what is their real significance beyond the hype that, understandably, surrounds any technological achievement that touches language, a most distinctive aspect of ours as humans. This talk will go through significant moments of the attempt at building machines that show capabilities similar to the ones of the human brain. It will do that using the particular perspective of someone who was active in AI in the early 1990s, teaching a course on it at Rhodes University, while trying to get a machine to compose music.

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Guidelines for Managing and Utilizing Generative Artificial Intelligence Writing Tools

Raymond Greenlaw[a]
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Abstract

The talk begins with a brief history of artificial intelligence (AI). Students use AI generative writing tools such as ChatGPT to complete their writing assignments, regardless of whether such tools are allowed or not. The quality of writing produced by such AI tools is superior to that of many university students in terms of grammatical correctness, reduced spelling errors, increased average word length, expanded vocabulary, improved and more varied sentence structure, decreased word repetition, and increased punctuation usage. In this talk I provide

guidelines for instructors, suggesting ways in which AI generative writing tools can be used to improve student writing. I discuss how to make students better editors, so they can improve ChatGPTs output or tailor it to specific needs. I provide insights on how to make students better fact checkers, so that they can eliminate hallucinations that AI writing tools generate. These errors of fact make the AI writing tools far less valuable than they would be otherwise. The talk highlights the need across a curriculum to focus writing exercises more on editing and fact checking. I provide numerous insights into programs such as ChatGPT to help instructors without a technical background identify, understand, and process student writing generated by such programs in an improved fashion. I discuss several tricks that students use to disguise writing produced by ChatGPT.

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Top-10 South African Fine Wines: To drink or to invest?

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Abstract

Wine is a beverage to drink but some wines are also an experience, something more than just a drink. Because exquisite wines are expensive and can yield remarkable investment appreciation, many people consider wine not only a semi-luxury drink but also a profitable capital investment. This market has received not only attention from the stakeholders (producers and consumers) but also from the financial world, in particular from speculators, arbitrageurs and fund managers specialised in alternative investment. In this study we construct a new South African Fine Wine (SAFW10) index based on top 10 wines that confirm high-quality, liquidity and highly desirable asset. We examine the effects of adding this new wine index to a broader investment portfolio. Our analysis reveals that including South African wine assets can improve portfolio growth rates. This study is the first attempt to develop a wine index in the South African market, adding a valuable option to the financial instruments available to investors in the South African financial markets.

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Classes of high dimensional Bernoulli distributions with given identical margins

Roberto Fontana[a]

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Abstract

The main contributions of the work (joint with P. Semeraro, Politecnico di Torino) are algorithms to sample from multivariate Bernoulli distributions and to determine the distributions and bounds of a wide class of indices and measures of probability mass functions. Probability mass functions of exchangeable Bernoulli distributions are points in a convex polytope, and we provide an analytical expression for the extremal points of this polytope. The more general class of multivariate Bernoulli distributions with identical marginal Bernoulli distributions with parameter p is also a convex polytope. However, finding its extremal points is a more challenging task. Our novel theoretical contribution is to use an algebraic approach to find a set of analytically available generators.

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Decentralized risk sharing: pooling risks without a central insurer

Jan Dhaene[a]

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Abstract

In this talk, we give an overview of some recent results on decentralized risk-sharing, which is an alternative for the centralized insurance approach. We consider risk-sharing pools where each participant is compensated from the pool for his loss and pays in return an ex-post contribution to the pool. The contributions of the participants follow from an appropriate risk-sharing rule, which is chosen such that the pool is self-financing. Decentralized risk-sharing revives early forms of mutual insurance and has been applied for centuries in traditional communities. The recent interest in a sharing economy, collaborative consumption and decentralized finance, together with recent advances in technology have made decentralized risk-sharing a viable candidate to disrupt the traditional insurance sector. We introduce and discuss a list of relevant properties of risk-sharing rules. A number of candidate risk-sharing rules are considered, including the simple uniform risk-sharing rule, as well as the conditional mean risk-sharing rule and the quantile risk-sharing rule. Their compliance with the proposed properties is investigated. Also, axiomatic characterizations of the above-mentioned risk-sharing rules are considered.

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Nonparametric Methods in Survival Data Analysis

Samuel Manda[a]

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Abstract

The Cox proportional hazards regression is widely used to model survival time in statistical sciences research. Useful extensions to the model include the frailty Cox proportional hazards regression models incorporating unobserved heterogeneity or random effects into the survival analysis. In this presentation, we describe some nonparametric methods for the analysis of survival data, including the estimation of the survival function and frailty distribution.

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A Glance at the Landscape of Contemporary Graph Theory

Eunice Gogo Mphako-Banda[a]

[a] Member of the African Mathematical Union (AMU), Southern Africa Mathematical Sciences Association (SAMSA), and South Africa Women in Science and Engineering (SAWISE).

Abstract

Graph theory is a dynamic and versatile field of mathematics, evolving rapidly because of its wide range of applications. It offers powerful tools for solving real-world problems and advancing scientific understanding. In this talk, well begin by exploring how some graph-theoretical concepts are used in various areas of mathematics, providing a foundation for understanding the interconnectedness of different mathematical disciplines. Then, well dive into applications in computer science such as data structures, algorithms, and network design. Finally, well touch on some applications in biology and drug design, such as modeling biological networks and understanding molecular structures and interactions, aiding in the development of drugs for effective treatments.

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GUHA Reveals Secrets of Data

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Abstract

In data mining, the aim is to find relations, associations, patterns, trends, and anomalies in data, here a flat matrix with rows and columns, whose cells can contain any symbols. GUHA is a particular data mining method introduced in 1960s. GUHA is based on logic formalisms, not in statistics; associations found in the data are either true (supported by the data) or false (not supported by the data). The truth value of an association is based on contingency tables: there are millions of them based on the data. LISp-Miner is a software that takes the data as an input (preprocessed by the user), goes through it and outputs those that are true. We briefly present the mathematical foundations of GUHA logic, and then in detail a project that utilized GUHA data mining.

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On $k + n^{\star}D$-Operator

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Abstract

In this paper, we introduce the class of $k + n^{\star}$D-Operator. A bounded linear operator T is said to be a $k + n^{\star}D$-Operator if $T^{\star 2k+n}(T^D)^2 = (T^D T^{\star})^2$ for positive integers n and k. We investigate the basic properties of this class and also show that this class is closed under strong operator topology. We use adjoint properties of bounded operator T. Results show that these class converges to the strong operator Topology.

Keywords: Operator, D-operator, *D-operator, Class (Q), $K^{\star}D$-operator

Category: **Algebra**

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The Impact of Algebra Tiles on Grade 10 Learners' Understanding of and Ability to Present and Manipulate Algebraic Expressions.

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Abstract

Despite the significance of mathematics as a compulsory subject, there are still challenges in its teaching and learning to which research must find solutions. One of the areas of school mathematics that learners still find more abstract and difficult to understand is algebra. This is because algebra appears to be more concrete than other areas of mathematics. One way to make algebra more concrete is to incorporate concrete materials or manipulatives in teaching.

The main objective of this study was to assess the impact of manipulatives-Algebra Tiles on learners' understanding of algebra by comparing lessons in which algebra tiles were used with the traditional procedure-based instruction in which no manipulatives were used. The study was quasi experimental whereby both groups sat for a pre-test before the teaching was done over a two weeks time period. In the last lesson at the end of the two weeks, all participants were tested on how well they have learnt to represent and manipulate algebraic expressions, including solving equations. Although there was no statistically significant difference in the overall performance between the two groups, within-group comparisons between the pre-test and post-test revealed that the experimental group made greater improvements. This is an indication that algebra tiles had an impact on learners' understanding of algebraic concepts and their ability to represent algebraic expressions and solve algebraic equations. Recommendations for both teaching approaches and further research are brought forth, in order to further explore the teaching and learning of algebra through the use of algebra tiles.

Keywords: proficiency, understanding, algebraic expressions, solving algebraic equations, manipulatives and algebra tiles.

Category: **Algebra**

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Rational homotopy of a map of projective quaternions and their relative Gottlieb groups.

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Abstract

In this paper, we show in terms of Sullivan models that the rational homotopy of a map $l : \mathbb{H}P^m \hookrightarrow \mathbb{H}P^{m+r}$ between projective quaternion spaces is a product of a quaternion projective space and odd spheres. We also study the properties of a map $\text{aut}_1\mathbb{H}P^m \to \text{maps}(\mathbb{H}P^m, \mathbb{H}P^{m+r}; l)$ and its G -sequence.

Keywords: Evaluation subgroups, L_∞ algebra, mapping spaces.

Category: **Topology**

References

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[4] D. Sullivan, Infinitesimal computations in topology, Publ. Math. IHES. 47 (1977), 269-331.

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Ramsey-type theorems for semigroups in pointfree topology.

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Abstract

Ramsey theory has influenced many areas of mathematics such as algebra, geometry, number theory and logic. In this talk we discuss some new Ramsey-type theorems for semigroups in the category of locales (i.e localic semigroups) - which can be viewed as the pointfree analogue of topological semigroups.

Keywords: Ramsey theory, pointfree topology, semigroups.

Category: **Topology**

References

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[2] Ramsey, F.P. (1930), "On a problem of formal logic", Proceedings of the London Mathematical Society, 30:264-28

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EQUIVARIANT MOTIVES VIA THE BOREL CONSTRUCTION.

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Abstract

We construct an equivariant version of Ayoub's triangulated categories of mixed motives for rigid analytic varieties under the action of a rigid analytic group. This is achieved by replacing the rigid analytic variety X with its simplicial Borel construction $EG \times_{/G} X$, and then restrict to Cartesian motives to ensures that the resulting category aligns closely with the original non-simplicial setting. Additionally, we explore an alternative approach to defining equivariant categories of motives using finite-dimensional approximations, which is equivalent to the Borel construction.

Keywords: Rigid analytic varieties, Borel construction, An algebraic derivator

Category: **Geometry**

References

[1] J. Ayoub, *Motifs des variétés analytiques rigides,* Mém. Soc. Math. Fr. (N.S.), (140-141), 2015.

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Constructing Fischer-Clifford matrices of a maximal subgroup $(22^{1+8}_{+}) : (U_4(2) : 2)$ of $F_{i_{22}}$ from its quotient group $2^9 : (U_4(2) : 2)$

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Abstract

The sporadic simple group Fi_{22} has a class of maximal subgroups of structure $\overline{G} = (2 \times 2^{1+8}_{+}) : (U_4(2) : 2)$. The Frattini subgroup $\Phi(P) = Z_2$ of the 2-group $P = 2 \times 2^{1+8}_{+}$ is characteristic in P and hence $\Phi(P) \triangleleft \overline{G}$. Therefore, the quotient group $\overline{Q} = \frac{\overline{G}}{\Phi(P)} \cong 2^9 : (U_4(2) : 2)$ exists. In this talk, the Fischer-Clifford matrices $M(g_i)$ of $\overline{G}$ are constructed from the corresponding Fischer-Clifford matrices $\overbrace{M(g_i)}$ of $\overline{Q}$, and we refer to this method as the lifting of Fischer-Clifford matrices.

Keywords: coset analysis, Fischer-Clifford matrices, split extension, inertia factor, character table

Category: **Algebra**

References

[1] F. Ali, Fischer-Clifford Theory for Split and Non-Split Group Extensions, PhD Thesis, University of Natal, 2001

[2] A. B. Basheer and T. T. Seretlo, On a group of the form 214:Sp(6, 2), Quaestiones Mathematicae, 39 (2016), 45-5

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On the Isomorphism of the Eulerian graph models due to the Algebraic Properties of the (132)-Avoiding class of AUNU Permutation Patterns.

Bentse P. Chun[a], **Danat T. Nanle**[b] & **Tyem N. Nimiel** [c]
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Abstract

In this article, the three Eulerian Graph models obtained from the adjacency tables (matrix) of the subsets of , the (132)- avoiding class of AUNU permutation patterns are examined as regard to whether they are Isomorphic or not. Two Graphs are said to be Isomorphic to each other if there exist a one to one correspondence between their vertices sets say and also between their edges sets say such that incidence relationship is preserved and written as . We first disregard the order of these graph models and consider them as undirected graphs. Next, the four basic requirements (conditions) for Isomorphism are now verified on these graph models to finally ascertain whether the said graph models are Isomorphic or otherwise.

Keywords: Graph, Directed and Un-directed graphs, Isomorphic Graphs, Eulerian Graphs, AUNU Permutation Patterns, Vertices, Edges, Incidence Relationship.

Category: **Algebra**

References

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Aspects of connectedness in Pointfree Topology.

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Abstract

A topological space X is said to be locally connected if only if each $x \in X$ has a neighbourhood base of open connected sets. In this talk we discuss several generalisations of local connectedness in the context of pointfree topology. In particular we discuss almost locally connected frames, Z-locally connectedness frames and sum connected frames. We show that all these frames in a zero-dimensional frame L coincide with local connected frames.

Keywords: Almost local connected, Z-locally connected, Sum connected

Category: **other**

References

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Maximality and resolvability among locales.

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Abstract

This study will investigate maximality and resolvability in spaces with a view to extending well known characterizations of maximality and resolvability in spaces to locales. We further analyze the two results and try to establishing the relationships between the two.

Keywords:frames, locales, (ir)resolvable, maximality

Category: **Topology**

References

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[4] E. Hewitt, *A problem of set-theoretic topology,* Degree of doctor of philosophy, Harvard Univ. (1942).

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Forecasting solar energy in the conditions of North-Mozambique atmospheric environment in short scale measurement.

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Abstract

It is estimated that around 733 million people worldwide live without access to electricity. On the other hand, the sustainable development goals aim to achieve global electrification by the end of 2030 and with the use of clean energy by 2050. In order to meet these goals, the adoption of alternative forms of energy, such as solar energy, which is stable and has abundant resources, would be of greater value. The lack of consistent maps of forecasting solar energy behavior locally and in the diaspora led to the objective of forecasting solar energy in the conditions of the North-Mozambique atmospheric environment in short scale measurement. The atmospheric parameters model was used, applied to machine learning models, such as: Random Forest,

Artificial Neural Networks, and Regression Kriging among others. The analyzed sample was collected in about three measurement stations during the years 2019, 2020 and 2021. The results show the transmittances and solar energy due to direct, diffuse and reflected energy parameters, with a high correlation between them in the order of 0.99, and a clear sky index defining mostly days of high solar radiation density with intermediate characteristics of magnitude 1. These results agree with those reported in the literature in Mucomole et. al. (2024) and Mucomole et. al. (2023), however here the determination of the forecast analysis is based on the estimated values. It can be concluded that the region has potential for exploitation and eliminates the problem of variability in photovoltaic production, however the methodology used here is ideal and can be applied in any conditions in the world in the diaspora. **Keywords:** Forecast, machine learning, solar energy, short-scale, North-Mozambique.

Category: **Theoretical physics**

References

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The Character Table of a Maximal Subgroup of the Chevalley simple group $G_2(4)$.

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Abstract

In this presentation, the character table of a maximal subgroup $\overline{G} = 2^{2+8} : (A_5 \times 3)$ of the Chevalley simple group $G_2(4)$ are computed using the Lifting of Fischer Matrices method [1,3]. The conjugacy classes of $\overline{G}$ are computed by the Coset Analysis technique [2].

Keywords: coset analysis, permutation character, fusion map, Fischer matrix.

Category: **Algebra**

References

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[3] A.L. Prins, Constructing Fischer matrices of an extension group from its underlying factor group, Adv. Group Theory and Appl., accepted.

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Remoteness of graphs and digraphs with given size and connectivity constraints

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Abstract

In a connected, finite graph G with order n and size m, the distance $d(u, v)$ between two vertices u and v is defined as the length of the shortest path between them. The average distance $\bar{\sigma}(v)$ of a vertex v is the mean distance from v to all other vertices in G, expressed as $\bar{\sigma}(v) = \frac{1}{n-1}\sum_{x\in V(G)} d(v, x)$. The remoteness $\rho(G)$ of a graph is the maximum average distance, given by $\max\{\bar{\sigma}(v) \mid v \in V(G)\}$.

Previous bounds on proximity and remoteness in terms of graph order were established by Aouchiche and Hansen [1], with Entringer et al. [2] providing stronger bounds considering both order and size. Additionally, the result in [1] was extended to digraphs in [3]. In this presentation, we establish sharp upper bounds on the remoteness of a κ-connected graph with given order and size. We further demonstrate that our proof approach extends to bounds based on edge connectivity for $\lambda \in \{2, 3\}$. Our findings also encompass bipartite graphs and a wide class of strong-digraphs, including all Eulerian digraphs. In each case, we prove that the bounds we provide are optimal.

Keywords: Remoteness; transmission; average distance; size; connectivity; edge-connectivity.

Category: **Graph Theory**

References

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Advancing the Sustainable Development Goals (SDGs) through the Use of Graph Theory in NodeXL: An Innovative Mathematical Approach.

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Abstract

The Sustainable Development Goals (SDGs) represent a global framework aimed at addressing pressing social, economic, and environmental challenges. This abstract explores the application of graph theory within NodeXL, a powerful network analysis tool, as an innovative mathematical approach to advancing the SDGs. Graph theory offers a unique lens for understanding complex relationships and interactions among various stakeholders involved in sustainable development, including governments, NGOs, and local communities. By modeling these relationships as networks, we can identify key influencers, assess the flow of resources, and uncover potential collaborations. The integration of NodeXL allows for the visualization and analysis of large datasets, enhancing our ability to derive actionable insights from social media, economic transactions, and environmental data. This approach enables policymakers and practitioners to make informed decisions, tailor interventions, and measure progress towards the SDGs more effectively. The abstract highlights case studies that demonstrate the successful application of graph theory in real-world scenarios, showcasing its potential to foster collaboration and innovation. Ultimately, leveraging graph theory through NodeXL can catalyze transformative actions towards achieving the SDGs, emphasizing the importance of interdisciplinary approaches in tackling complex global challenges.

Keywords: Sustainable Development Goals (SDGs), graph theory, NodeXL, network analysis, mathematical modeling, stakeholder collaboration, data visualization, policymaking, interdisciplinary approaches.

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Edge-connectivity of the square of a graph.

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Abstract

Let G be a connected graph. The edge-connectivity of G, denoted by $\lambda(G)$, is the minimum number of edges whose removal renders G disconnected. Let $\delta(G)$ be the minimum degree of G. It is well-known that $\lambda(G) \leq \delta(G)$, and graphs for which equality holds are said to be maximally edge-connected. The square G^2 of G is the graph with the same vertex set as G, in which two vertices are adjacent if their distance is not more that 2.

We present results on the edge-connectivity of the square of a graph. We show that if the minimum degree of a connected graph G of order n is at least $\lfloor \frac{n+2}{4} \rfloor$, then G^2 is maximally edge-connected, and this result is best possible. We also give lower bounds on $\lambda(G^2)$ for the case that G^2 is not maximally edge-connected: We prove that $\lambda(G^2) \geq \kappa(G)^2 + \kappa(G)$, where $\kappa(G)$ denotes the connectivity of G, i.e., the minimum number of vertices whose removal renders G disconnected, and this bound is sharp. We further show that $\lambda(G^2) \geq \frac{1}{2}\lambda(G)^{3/2} - \frac{1}{2}\lambda(G)$, and we construct an infinite family of graphs to show that the exponent $3/2$ of $\lambda(G)$ in this bound is best possible.

Keywords: graph, edge-connectivity, square.

Category: **Graph Theory**

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Some notes on countable strongly annihilated ideals of the pointfree function ring $\mathcal{RL}$

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Abstract

In the paper Countable Strongly Annihilated Ideals in Commutative rings by Mohamadian [1], the concept of Countable strongly annihilated ideals is introduced in a commutative ring A and also studied in the ring $C(X)$ of continuous functions on a topological space X. In this talk, we study these ideals in the pointfree function ring $\mathcal{RL}$ and give a relationship of these ideals with other ideals such as z-ideals, d-ideals, real maximal ideals and strongly divisible ideals. We characterise almost P-frames and pseudocompact frames in terms of countable strongly annihilated ideals. Furthermore, we investigate the relationship between strongly annihilated ideals and the annihilating content for an ideal studied in [2] in the context of the ring $\mathcal{RL}$.

Keywords: z-ideal, d-ideal, ream maximal ideal, strongly divisible ideal, almost P-frame, pseudocompact frame.

Category: **other**

References

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ANALYSIS OF INCOME DISPARITIES IN NAMIBIA.

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Abstract

Understanding the mechanisms of poverty and inequality in Namibia requires research on an analysis of income disparities in Namibia using data from the 2015/16 Namibia Household Income and Expenditure Survey (NHIES), that was conducted by the Namibia Statistics Agency.

The main objective of the study was to investigate the household income disparities in Namibia. Specific objectives were to examine the association between household income and sociodemographic characteristics and to explore the effects of socio-demographic factors on household income.

The Pearson chi-square test for association was used to investigate potential correlations, and an ordinal regression model was used to examine associations between household income and socio-demographic factors in a cross-sectional quantitative study design. The study used secondary data (NHIES) obtained from the Namibia Statistics Agency data catalogue. The findings show significant disparities, with female-headed households earning significantly less than male-headed households. Marital status is also a strong predictor, with married households generally earning more than those led by single or cohabiting individuals. Educational attainment is positively correlated with income, while households with no formal education are concentrated in the lower income brackets. Additionally, urban households and those in regions like Khomas were found to have higher incomes than rural households or those in regions like Kavango. Language also plays a critical role, with English-speaking households generally earning more than those speaking indigenous languages. Given the significant p-values $(p < 0.05)$, important sociodemographic variables are statistically significant.

Based on these findings, the study recommends policies aimed at closing the gender wage gap, promoting educational access, and addressing income disparities. Strengthening social protection programs for low-income households, especially those led by women, and investing in rural

development are also suggested. **Keywords:** Household, Income, Namibia, Socio-economic, demographic.

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Radical Characterization of the Weyl and Browder Elements in Banach Algebras

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Abstract

In 1971, Lebow and Schechter (see [1]) came up with a new characterization of the radical ideal in a Banach algebra by establishing perturbation of certain subsets of Banach algebra. If A is a Banach algebra with A^{-1} representing set of all invertible elements in A, it was discovered that the perturbation of A^{-1} is equal to the radical ideal of A. This result was used to obtain many more perturbation results in [1], and more recently in [2]. The Weyl and Browder elements relative to a closed ideal I are open subsets of A. In this talk we show the radical characterization of these elements relative to closed ideal I, using the approach in [1]. We analyse more results if we let I is to be a closed trace ideal in A, we establish more perturbation ideals of Weyl elements relative to I and if J is a closed inessential ideals, we establish more perturbation ideals of the Browder elements relative to J.

Keywords: Weyl elements, Browder elements, Perturbation, Radical, Ideal

Category: **Analysis**

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DEVELOPMENT OF A BLOCK METHOD FOR SOLVING MULTIPLE ORDER ODES.

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Abstract

In this work, a convergent hybrid block method (CHBM) with two off-grid points for direct integration of first, second, and third-order initial value problems (IVPs) is proposed. The development of a block method for the solution of IVPs has been considered overwhelmingly in the literature. However, using a block method to directly solve multi-order IVPs has not been so common. Thus, the formulation of a single numerical algorithm for the direct numerical integration of first, second and third-order IVPs is our focus. The method is formulated from a continuous scheme derived using collocation and interpolation techniques and implemented in a block-by-block manner as a numerical integrator for IVPs. To assess the method's applicability, efficiency, and accuracy, the convergence analysis has been investigated, and six test problems are considered.

Keywords: Block method, Collocation, Consistency, Convergence, Error Constant, Interpolation, IVPs, Hybrid method, ODEs, Zero-Stable

Category: **Analysis**

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[2] Benth, F. E. and Simonsen, I. C. (2018):The Heston stochastic volatility model in Hilbert space. *Stochastic Analysis and Applications*.

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Viscosity Approximation Method for Mean Valued Iteration and Split Monotone Variational Inclusion Problem in Hilbert Spaces and Applications.

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Abstract

In this paper, we propose a modified viscosity approximation method involving Cesaro mean valued iteration of finite commutative normally n-generalized hybrid mappings and split monotone variational inclusion problems in the setting of Hilbert spaces. We then prove that a sequence generated by the method converges strongly to a common element in the solution set of split monotone variational inclusion problem and fixed point of the said class of mappings in the

spaces. As application, we established strong convergence theorem for finite commutative normally 2 generalized hybrid mappings. Our results extend and generalized many corresponding ones announced in this direction..

Keywords: Normally n-generalized hybrid mapping, Mean valued iteration, Split monotone variational Inclusion problem, Viscoty approximation method

Category: **other**

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Travelling solutions and conserved vectors of the Lonngren wave equation for communication signals.

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Abstract

The Lonngren wave equation, which is a fourth-order nonlinear partial differential equations, is a mathematical model that is used for simulating electrical signals in semiconductor materials, with specific emphasis on the tunnel diode. In this talk we obtain exact solutions and conserved vectors of the equation. Lie symmetry method [1, 2] along with some other specialized techniques such as Jacobi elliptic expansion technique will be invoked to construct closed-form solutions. Moreover, the multiplier method [2] and the conservation theorem introduced by Ibragimov [3] will be employed to derive the conserved vectors of the underlying equation.

Keywords: Lonngren wave equation, Lie symmetry method, exact solutions, conservation laws, multiplier method

Category: **Analysis**

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Conservation laws and analytic solutions of the generalized geophysical Korteweg-de Vries equation.

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Abstract

The generalized geophysical Korteweg-de Vries equation (gGKdV), which is a third-order nonlinear partial differential equations, is a mathematical model that is used to explore earths rotation on the propagation of oceanic waves. In this talk we obtain conservation laws and analytic exact solutions of the equation. Noethers theorem [1] will be employed to derive the conserved vectors of the underlying equation. Furthermore, Lie symmetry method [2, 3] will be invoked to construct analytic solutions of the equation.

Keywords: Generalized geophysical Korteweg-de Vries equation, Lie symmetry method, analytic solutions, conservation laws, Noethers theorem.

Category: **Analysis**

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A SEVENTH "ORDER COMPUTATIONAL ALGORITHM FOR THE SOLUTION OF STIFF SYSTEMS OF DIFFERENTIAL EQUATIONS.

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Abstract

In this paper, we present a computationally cheap second derivative block hybrid method for the numerical solution of systems of stiff initial valued ordinary differential equations. Results of numerical experiments which validates our theoretical results are presented by figures and tables.

Keywords: differential equations, hybrid method , Stiff system

Category: **Analysis**

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Theoretical analysis of the effect of binding Schiff based ligand on Ruthenium benchmark Dye on Photo -response properties for DSSCs potential.

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Abstract

Energy consumption is in demand across the Globe. The population number is increasing yearly, and source of this energy consumption becomes daunting. The current fossil fuel as a source of energy is becoming detrimental to the environment. Solar energy utilisation has become an alternative source of energy. Solar cells have been developed to assist in harvesting this energy. Hence, the photovoltaic technology has emerged and evolved drastically. The dye-sensitiser solar cells have become of one the devices that are environmentally friendly in the quest to harvest solar energy. The DSSCs are third generation of PV solar cells. They have a great advantage of harvesting light even in dim situations. However, the molecular dye conversion efficiency is relatively low ranging from 12-13efficiency, therefore is a need for improvement. The dye molecules are manipulated to increase the charge transfer rate through decreasing the HOMO-LUMO gap to achieve high absorption intensity as well as absorption near the IR region. A Schiff base ligand and its corresponding ruthenium dyes are investigated theoretically on B3LYP/6-31G* both on DFT and TD-DFT, where LANL2DZ was an effective core potential on core and as a basis set on valence orbitals of ruthenium metal. It is greatly observed that binding ligand on ruthenium benchmark dye influence the photo response and the selected ligand with it dyes molecules could be of potential use in the DSSCs.

Keywords: Schiff base ligand, ruthenium benchmark dye, DSSCs

Category: **Analysis**

References

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ITERATED FUNCTION SYSTEM OF GENERALIZED CYCLIC CONTRACTIONS IN PARTIAL METRIC SPACES.

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Abstract

We generate a fractal using a finite collection of generalized cyclic contraction mappings, belonging to a particular category of mappings defined on a partial metric space. As a consequence, different results are attained for iterated function system that satisfy a different set of generalized cyclic contraction conditions. To substantiate the proven results, an example together with some applications are presented. With these results, we extend, unify and generalize some common results in contemporary literature.

Keywords: Iterated function system, partial metric space, attractor, fixed point, cyclic contraction

Category: **Analysis**

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Properties of Bishop - Phelps cone in Banach spaces.

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Abstract

We prove that in any non - reflexive Banach space, there exists a non - solid cone whose dual satisfies the angle property. This gives a positive answer to the question of J Qiu. The question was partially answered by I. Polyrakis et. al for separable spaces. Here we present different proof for separable spaces and then extend it to non - separable spaces. In particular we first show that any non - reflexive Banach space contains a BP cone that is isomorphic to ℓ_1^+. Finally we show that its dual has a bounded base and so satisfying the angle property.

Keywords: BP cone, bases for cones, angle property, dual wegde, reflexive space

Category: **Analysis**

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Estimating Concurrent Probabilities of Compound Extremes: An Analysis of Temperature and Rainfall Events in the Limpopo Lowveld Region of South Africa.

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Abstract

In recent years, there has been increasing interest in the joint modelling of compound extreme events such as high temperatures and low rainfall. The increase in the frequency of occurrence of these events in many regions has necessitated the development of models for estimating the concurrent probabilities of such compound extreme events. The current study discusses an application of copula models in predicting the concurrent probabilities of compound low rainfall and high temperature events using data from the Lowveld region of the Limpopo province in South Africa. The second stage discussed two indicators for monitoring compound high temperature and low rainfall events. Empirical results from the study show that elevations ranging from 100-350m, 350-700m and 700-1200m exhibit varying probabilities of experiencing drought, with mild droughts having approximately 64%, 66%, and 65% chances, moderate droughts around 36%, 39%, and 38%, and severe droughts at approximately 16%, 19%, and 18%, respectively. Furthermore, the logistic regression models incorporating the southern oscillation index as a covariate yielded comparable results of copula-based models. The methodology discussed in this paper is robust and can be applied to similar datasets in any regional setting globally. These findings could be useful to disaster management decision makers, helping them formulate effective mitigation strategies and emergency response plans.

Keywords: bivariate extremes; copulas; drought; joint extreme events; rainfall deficit; temperature

Category: **Analysis**

References

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Latent class analysis of risk factors for acquiring HIV among adolescent girls and young women: A case of DREAMS program in Zimbabwe.

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Abstract

Background: Adolescent girls and young women (AGYW) aged 10-19 years remain at high risk of human immunodeficiency virus (HIV) with low resource settings deeply affected. In sub-Saharan Africa, AGYW accounts for 25% of new infections despite constituting 10% of the total population. Latent Class Analysis (LCA), a statistical modelling technique classifies variables for decision making purposes.

Methods: We conducted LCA to model risk of vulnerability to HIV among AGYW enrolled in the Determined, Resilient, Empowered, AIDS-free, Mentored, and Safe (DREAMS) program in Zimbabwe using poLCA package, an add on to R-studio. An LCA model was developed and association between different classes and vulnerability to HIV were determined.

Results: Study findings demonstrated the intensity of LCA in grouping vulnerabilities to HIV among AGYW. We found five distinct classes for vulnerability to HIV among 1014-year-old AGYW, and three classes for 1519-year-old AGYW. AGYW in higher vulnerability to HIV classes constituted 47.7% of the 1014-year-old AGYW and 43.7% of the 1519-year-old AGYW. Highly vulnerable classes had AGYW who were single, those in rural areas, those who use drugs and alcohol, and those engaged in transactional sex.

Conclusion: LCA modeling is a powerful tool for classifying risk to HIV among AGYW in low resource setting. Such classifications are very critical in customizing interventions to specific vulnerable groups of AGYW to reach HIV epidermic control. We recommend customized interventions for AGYW who use alcohol and drugs, with school dropout risk, engaged in transactional sex and those who resides in rural areas. **Keywords:** Latent class analysis, HIV,

DREAMS, model, AGYW.

Category: **Analysis**

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Bulk-surface finite element methods for non-linear semi-parabolic partial differential equations of reaction-diffusion type.

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Sekgothe H

We develop bulk-surface finite element methods for generalised reaction-diffusion systems and explore higher order finite elements disctretisations. The finite element algorithms will be implemented in FeNiCs.

Keywords: Bulk-surface reaction-diffusion systems, Finite element method

Category: **Numerical analysis**

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Comparison of the discrimination and calibration performance of the Logit-power and Pareto families of link functions in discrete survival models: A Bayesian Approach.

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Abstract

Discrete survival models describe the hazard of an event at a given time point as a function of covariates through a link function. Traditionally, the inverse CDFs of distributions such as the logistic, probit, or Gumbel are used as link functions. However, incorrect specification of the link function can lead to biased parameter estimates and poor model performance. To address this, flexible families of link functions, like the Logit-power and Pareto families, or non-parametric links, have been proposed as alternatives. In a previous study using a frequentist estimation approach, we compared these two families and observed imprecision in the estimation of the family-specific parameters, potentially impacting model predictive performance. In this study, we adopt a Bayesian approach to estimation, aiming to improve parameter precision and, consequently, the predictive power of the models. We provide a comparison of the discrimination and calibration performance of the Logit-power and Pareto link families within the Bayesian framework, while also contrasting the results with those obtained using the frequentist estimation approach.

Keywords: Discrete survival model, Families of Link functions, Discrimination, Calibration, Bayesian estimation.

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Socio-demographic Variation on Age-Specific Fertility in Namibia an Analysis of the 2013 Namibia Demographic Health Survey.

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Abstract

Gaire et al. defines "Age-Specific Fertility Rate" (ASFR) as the number of births to females in a particular age category in a particular year compared to the number of females in that age category. This study uses data from the 1992, 2000, 2006 and 2013 Namibia Demographic and Health Survey to examine the effects of socio demographic and socio-economic factors on the total number of births in the last 72 months preceding the survey in Namibia. Model of negative binomial regression was employed to identify the main variables of fertility in women of different ages. The findings indicate that the total number of births in Namibia are significantly influenced by socio demographic and socio-economic variables such as wealth index, highest educational level, religion, marital status, and employment status. Furthermore, the study shows significant differences in fertility rates across women living in rural and urban areas, as well as across the regions. Significant factors impacting fertility include age of the woman. These results highlight the important sociodemographic and socio-economic variations influencing Namibia's fertility patterns. According to the research, fertility strategies need to concentrate on improving women's access to education and work possibilities in order to solve the larger socioeconomic problems that they face. Improving reproductive health services is also necessary, especially in rural regions where access to quality treatment is limited. Namibia can effectively limit fertility rates and achieve more equitable development outcomes by placing a high priority on improving the socioeconomic condition of women.

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OPTIMAL INVESTMENT DECISION MAKING UNDER TWO FACTOR UNCERTAINTY USING LEVY PROCESSES

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Abstract

This research paper explores the use of real options theory to optimize investment decisions under two-factor uncertainty, with revenue and cost modelled using Lvy processes. Traditional methods such as net present value (NPV) models frequently underestimate the complexities of uncertain circumstances. In contrast, real options theory offers a dynamic and adaptable framework for investment analysis. By extending the mathematical framework from [**?**] to include jump diffusions and the optimal stopping of such processes, this paper creates a comprehensive model for making investment decisions in uncertain environments. The research covers a thorough examination of stochastic calculus with Lvy processes, financial markets with jump diffusions, and optimal stopping theory. Furthermore, numerical methods are used to solve the resulting partial differential equations (PDEs), which provide useful insights into investment strategy.The findings advance our understanding of optimal decision-making in uncertain financial markets.

Keywords: Lévy Processes, Optimal stopping, Real options, Two factor uncertainty, Investment decisions

Category: **Mathematics of Finance**

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Two pension fund managers that compete in a Nash equilibrium portfolio game under the jump diffusion model

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Abstract

In this study, we investigate the stochastic Nash equilibrium portfolio game between two pension funds under the jump diffusion mode. The financial market is assumed to contain risk free asset and two stocks whose price process follow a jump diffusion process. The pension managers aim to to maximize the expected utility of the real terminal wealth under the jump diffusion model. We use the dynamic programming method to derive the Nash equilibrium strategies. Finally, a numerical analysis is computed to show the economic performance of the two DC pension funds.

Keywords: Pension funds, game theory, Jump diffusion

Category: **Mathematics of Finance**

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AI-Driven Derivatives Pricing Models in Fintech.

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Abstract

The rapid progress of AI in fintech has revolutionized the financial industry. AI has demonstrated its potential in the area of derivatives pricing. Legacy pricing strategies face significant challenges in processing vast data sets and adequately reflecting market shifts. This research examines the various AI-powered pricing models for derivatives, highlighting their pros, cons, and practical use cases in the fintech industry. By delving into Monte Carlo & Neuronetworks estimation techniques specifically, we gain insight into how AI can be leveraged to price derivatives. Financial pricings fundamental concept, derivative pricing, sees fresh avenues with AI and Monte Carlo methods. This research delves into the theoretical underpinnings and real-world applications of Monte Carlo & Neuronetworks estimation in valuing derivatives, with a special emphasis on breaking down intricate mathematical concepts.

Keywords: AI-Derivative Pricing Model,Complexity of market variables ,Volatility, interest rates, Generative AI, Black-Scholes model, Dynamic financial markets.

Category: **Mathematics of Finance**

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Fluid Structure Interaction (FSI): From Basic Theory Concepts to Specific Model Problems

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Abstract

In this work we start by introducing the necessary basic concepts that can lead us to solve a fluid-structure interaction (FSI) problem.
Then, specific mathematical models, in biological systems and gas dynamics, are presented.
For biological systems, a one dimensional mathematical model of a cerebral aneurysm is presented. Finite Difference Method is used for numerical simulations.
In gas dynamics, a one dimensional piston problem is presented. For numerical simulations we start by presenting an algorithm for the strong coupling of fluid-structure interaction using a staggered scheme. Finally, implicit-explicit higher order time integration approaches are used for numerical simulations.

Keywords: Fluid-Structure Interaction, Cerebral Aneurysm, Piston Problem, High Order Time Integration

Category: **Industiral Mathematics**

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Solving Lane-Emden equations with boundary conditions of various types using high-order compact finite differences

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Abstract

In this study, a high-order compactfinite difference method is used to solve Lane Emden equations with various boundary conditions. The norm is to use a first-order finite difference scheme to approximate Neumann and Robin boundary conditions, but that compromises the accuracy of the entire scheme. As a result, new higher-order finite difference schemes for approximating Robin boundary conditions are developed in this work. We test the applicability and performance of the method using different examples of Lane-Emden equations. Convergence analysis is provided, and it is consistent with the numerical results. The results are compared with the exact solutions and published results from other methods. The method produces highly accurate results, which are displayed in tables and graphs.

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Criminodynamics: Modeling crime in communities and correctional facilities

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Abstract

This study presents a differential equation model to simulate and analyze the dynamics of criminal activities within communities and correctional facilities. The model considers interactions between individuals in the community, including both law-abiding citizens and criminals, as well as the effects of incarceration and rehabilitation in correctional facilities. The main focus is on identifying steady states of criminal behavior under various scenarios, including different levels of law enforcement, rehabilitation effectiveness, and social interactions. Mathematical analysis techniques, such as stability analysis and bifurcation theory, are employed to characterize the equilibrium points and their stability. Furthermore, numerical simulations are conducted to validate the theoretical findings and explore the transient dynamics of the model. These simulations provide insights into how parameter changes affect crime rates over time and the effectiveness of intervention strategies. Overall, this research contributes to understanding the complex dynamics of crime within communities and the impact of correctional services, offering a quantitative framework for policy-makers and law enforcement agencies to develop more effective crime prevention and rehabilitation strategies. **Keywords:** Crime dynamics; Mathematical model; Stability analysis; correctional facilities; Simulations.

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An Atangana-Baleanu Fractional Model of Youth Unemployment in the COVID-19 Era.

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Abstract

This study develops a system of ordinary differential equations (ODEs) to model the dynamics of youth unemployment, a critical issue that needs urgent solutions. Given the exacerbating impact of COVID-19 on all sectors of economic activity, the derived is model is extended to an AtanganaBaleanu fractional (ABF) framework to better capture the complex unemployment dynamics. The ABF dynamics are analyzed, establishing certain conditions that indicate the potential for eradicating or persisting unemployment. These conditions are earmarked for in-depth discussion in the implementation phase of the AB fractional dynamics. As an analytic solution for these dynamics remains unavailable, a numerical method is derived to discretize the AtanganaBaleanu fractional derivative in the Caputo sense. This method is analyzed for convergence, implemented, and its results are presented for further examination.

Keywords: Youth Unemployment, AtanganaBaleanu Fractional Dynamics, COVID-19 Economic Impact, Eradication of Unemployment, Persistence of Unemployment.

Category: **Epidemiological and Socio-economic Modeling.**

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OPTIMIZING RUIN PROBABILITY THROUGH REINSURANCE WITH INCLUSION OF INVESTMENT AND DIVIDEND PAYMENTS.

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Abstract

The study investigated "Optimizing Ruin Probability Through Reinsurance with Inclusion of In vestment and Dividend Payments." It aimed to understand the role of investments in reducing the risk of ultimate ruin for insurance companies, evaluate the effects of proportional reinsurance on their survival, and determine the optimal reinsurance percentage $b \in (0, 1]$ and $a \in [0, \infty)$. The study examined a risk process combining a diffusion-perturbed insurance model and a Black Scholes investment model. It derived the Hamilton-Jacobi-Bellman (HJB) equation and trans formed it into a linear Volterra integral equation. Using a block-by-block numerical method, the researchers calculated the retention percentage that minimizes the risk of ultimate ruin.

Keywords: Reinsurance, Ruin Probability, diffusion-perturbed insurance model.

Category: **Mathematics of Finance**

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Pathwise local times for deterministic cadlag deterministic paths as normalised numbers of interval crossings

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Abstract

We establish the relationship between the normalised number of interval crossings by a cadlag path and an occupation measure associated with the path. We then use this result to define the local times of deterministic cadlag paths as weak limits of properly normalised numbers of interval crossings. We then give an example of a function derived from the Cantor function where the relationship between the numbers of normalised interval crossings and occupation

measure holds but theres no local. We also give an example of a function derived from the Cantor function where the relationship holds, and the local time exists.

Keywords: normalised interval crossings, cadlag paths, occupation measure, pathwise stochastic calculus

Category: **Mathematics of Finance**

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The role of Algebra in the effective teaching and learning of trigonometric identities in Grade 12 Advanced Subsidiary level.

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Abstract

The examiners' reports for Grade 12 Advanced Subsidiary (AS) curriculum implemented in 2021 with its first examination in the same year, has annually been reporting that a significant number of candidates who enter this syllabus without a solid algebra foundation struggle to cope with many topics in AS course. This reality problematizes the fact that algebra is one of the core branches of mathematics. For example, many learners struggle to prove trigonometric identities such as $\frac{\sin 2x}{1+\cos x} = 1 - \cos x$ due to lack of solid algebra foundations or inability to apply relational thinking in mathematics, like applying the difference of two squares on the numerator. A solid understanding of algebra constitutes an essential part of and contribute to effective learning of trigonometry in general and trigonometric identities in particular. This study emanated from the experience we had when teaching trigonometric identities to Grade 12 learners from different schools. The observation revealed that learners struggle to apply the knowledge on how to factorize, and simplify common factors when they interacted with questions that required them to prove the trigonometric identities. This observation was further supported by the review of examiners reports from 2021 to 2023. The study recommends that both appropriate pedagogical content knowledge and subject content knowledge be emphasized to mathematics teachers to provide a basis for learning how to prove trigonometric identities in the 21st century.

Keywords: Advanced subsidiary curriculum, examiners report, trigonometric identities, algebra, pedagogical content knowledge, subject content knowledge, 21^{st} century.

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Stochastic optimal control of a domestic islandic Microgrid management system equipped with solar panel, battery storage and a generator.

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Abstract

In this talk, we consider a domestic microgrid equipped with a local renewable energy production unit such as photovoltaic panels, consumption units, and a battery storage to balance supply and demand and investigate the stochastic optimal control problem for its cost-optimal management. Such systems are complex to control because, on the one hand, of the different components and interconnections, and, on the other hand, of uncertainties in the weather and environmental conditions which affect the production and demand of energy. As a special feature, the manager has no access to the grid but has access to a local generator, which makes it possible to produce energy using fuel when needed. Further, we assume that the battery and the fuel tank have limited capacities and the fuel tank can only be filled once at the beginning of the planning period. In addition, we assume that the energy demand is not always satisfied and we impose penalties on unsatisfied and pre-satisfied demand, the so called inconvenience cost. The managers decision consists of charging and discharging the battery or consume fuel. The main goal is to minimize the expected aggregated cost for generating power using the generator (by consuming fuel) and operating the system. This leads to a challenging mathematical optimization problem. The optimization problem is formulated first as a continuous-time stochastic optimal control problem for a controlled multi-dimensional diffusion process and the corresponding Hamilton-Jacobi-Bellman (HJB) equation is derived using dynamic programming methods. However, no analytical solution of the HJB equation can be.

Keywords: Stochastic optimal control, Cost-optimal management, Standalone microgrid, Markov decision process.

Category: **Mathematics Finance**

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Data Integration Method in the Regression Analysis of Vaccine Efficacy in Pneumococcal Colonisation Studies from Malawi and the UK.

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Abstract

We consider regression analysis to estimate the Pneumococcal Vaccine Efficacy in the context of integrating data from the Malawi Accelerated Research in Vaccine, Experimental, and Laboratory Systems (MARVELS) program and the UKs Experimental Human Pneumococcal Carriage (EHPC) studies. These data sets have different designs, study variable non-overlap, and the presence of multiple confounders. This analysis demonstrates the feasibility of data integration on heterogeneous datasets. Combining several data sources into the regression analysis for vaccine efficacy is an important statistical and clinical problem. It enables the identification of hidden interactions and more convincing evidence of vaccine efficacy. The resulting findings could inform more targeted and effective vaccination strategies.

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Dynamics of Gambling Information Diffusion and Its Impacts on Consumer Behaviors.

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Abstract

The rapid viral propagation of gambling information across various regions poses significant potential harm to society. This study investigates the diffusion of gambling-related information within four Namibian regions: Erongo, Khomas, Oshana, and Zambezi. The primary aim is to analyze the dynamics of information diffusion and its subsequent impact on consumer behavior, thereby highlighting the societal risks associated with this trend.The gambling population is categorized into distinct classes, including those who have never gambled, individuals who have heard about gambling but have delayed reacting, excessive gamblers, and skeptical gamblers. To elucidate the mechanisms underpinning gambling-related information and its impact on consumer behaviors, the study develops a comprehensive model employing mathematical modeling and empirical data. The model utilizes finite element methods for the numerical solution, which enables accurate simulation of the system's dynamics. Additionally, the study provides a critical threshold for understanding the diffusion of gambling information and its impact on consumer behavior.

Keywords: Gambling Information, Diffusion, Impacts, Critical Threshold.

Category: **Applied Mathematics**

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Magnetic Drug Targeting during Casson Blood Flow in a microvessel: A Caputo Fractional Model.

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Abstract

In the present study, a Caputo time-fractional derivative is introduced to the governing equation to present the flow of non-Newtonian fluid and the trajectories of drug carrier magnetic nanoparticles toward the diseased region. The rheology of blood is defined by the non-Newtonian Casson fluid. The flow of blood takes place in a straight axisymmetric microvessel. The governing momentum equation is solved analytically by using significant integral transforms like Laplace and finite Hankel transforms. The fourth order Runge Kutta (RK-4) method is used to solve the force balance equations, whereas the total volume fraction of magnetic nanoparticles is determined analytically. The study presents the impacts of different governing parameters on the capture efficacy of drug carrier magnetic nanoparticles and on the total volume fraction of magnetic nanoparticles. The study demonstrates that short time memory effect leads to a speedy move of the drug particles towards the disease region and the phenomenon is more significant with increase in the volume fraction of the magnetic nanoparticles, magnetization and permeable nature of the microvessel. A comparison of the present result with the previous work shows excellent agreement. The findings of the present study will be beneficial to the field of medical science to carry out further research to therapy disease in specific locations during magnetic drug targeting.

Keywords: Magnetic drug targeting, Caputo Fractional derivative, Casson fluid, Permeability.

Category: **Fluid Dynamics**

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Quantifying the impact and recovery of South Africa's manufacturing sales from the COVID-19 pandemic using a time series intervention model.

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Abstract

Intervention analysis plays a pivotal role in understanding the effects of significant events on time series data, providing essential insights for policy decisions and strategic actions. The South African manufacturing sector, a cornerstone of the nation's economy, was profoundly impacted by the COVID-19 pandemic. However, the extent and speed of its recovery still need to be explored. The aim is to apply a time series intervention model to quantify the impact and recovery of South Africa's manufacturing sales from the COVID-19 pandemic. The intervention point is identified as April 2020, marking the onset of the pandemics impact. A SARIMA (0,1,1)(0,1,1)12 model, incorporating an intervention component, was found to be the most suitable for this purpose, as evidenced by the Bayesian Information Criterion (BIC), root mean square error (RMSE), and mean absolute error (MAE). The immediate impact in April 2020 resulted in a significant 55.17reduction in manufacturing sales. The interventions effect was sudden but transient, with the sector recovering within approximately ten months. This analysis underscores the importance of contingency planning, such as embracing digital transformation and online sales strategies, to mitigate the impact of future disruptions which are likely to occur. The SARIMA intervention model provides a robust framework for identifying intervention points and assessing the effects of significant events across various industries, including but not limited to manufacturing.

Keywords: SARIMA model, intervention analysis, manufacturing sales, Covid-19 pandemic

Category: **Mathematical Biology**

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[2] Benth, F. E. and Simonsen, I. C. (2018):The Heston stochastic volatility model in Hilbert space. *Stochastic Analysis and Applications*.

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Deep Operator BSDE: a Numerical Scheme to Approximate the Solution Operators.

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Abstract

Motivated by dynamic risk measures and conditional g-expectations, in this work we propose a numerical method to approximate the solution operator given by a Backward Stochastic Differential Equation (BSDE). The main ingredients for this are the Wiener chaos expansion and the classical Euler scheme for BSDEs. We show convergence of this scheme under very mild assumptions, and provide a rate of convergence in more restrictive cases. We then implement it in practice using neural networks, and provide several numerical examples where we can check the accuracy of the method.

Keywords: BSDE, g-expectations, numerical methods for BSDE, Deep Learning.

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Optimization of Spectral Hybrid Method for Unsteady Reactive MHD Flow of Third-Grade Fluid through a Porous Medium with Asymmetrical Convective Cooling.

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Abstract

This study aims to enhance the efficiency and accuracy of the Spectral Hybrid Method (SHM) for analyzing unsteady reactive magnetohydrodynamic (MHD) third-grade fluid flows in porous media with asymmetrical convective cooling. We investigated optimization techniques for SHM that address the complexities of third-grade fluids and uneven cooling effects. Key parameters affecting method performance, including fluid viscosity, magnetic field strength, and porous medium porosity, will be identified and analyzed. Our goal is to develop refined algorithms that provide improved computational result

Keywords: Spectral Hybrid Method, magnetohydrodynamic, third-grade fluid, porous media, magnetic field

Category: **Applied mathematics**

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A typhoid epidemic model with resistance and antibiotic switching.

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Abstract

Typhoid fever continues to be a major public health concern, particularly in regions where sanitation infrastructure is inadequate. The rise in resistance to typhoid drugs makes treatment increasingly challenging, resulting in longer recovery times and ongoing transmission of the disease within households and communities. This growing resistance underscores the urgent need for improved treatment strategies and public health intervention. In this study, we presented a mathematical model of a typhoid fever that incorporates antibiotic resistance and the implementation of antibiotic switching as a control strategy. The model divides the infected population into three classes: those infected with antibiotic-sensitive strains, those infected with antibiotic-resistant strains, and those in treatment. The effects of antibiotic switching, which involves transitioning patients between different antibiotics, are modeled to study its impact on the prevalence of resistant and sensitive strains. The positivity and boundedness of the solution to the developed model are verified to ensure that the model equation is well-posed both mathematically and epidemiologically. Furthermore, we computed the model reproduction number R0, and stability analysis of equilibrium points for the full model and submodels are performed. Sensitivity analysis is performed to identify critical parameters that influence the persistence of typhoid in the population. Numerical simulations are performed to support the theoretical findings. The results obtained demonstrate that antibiotic switching can reduce the prevalence of resistant and sensitive strains and overall infection levels, highlighting their potential as an effective strategy to manage antibiotic resistance in typhoid fever. The results suggest that well-timed antibiotic switching can significantly reduce the spread of resistant strains and lower infection levels.

Keywords: Typhoid; Antibiotic resistance; Switching; Reproduction number; Numerical simulations.

Category: **Applied Mathematics**

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Seasonal Malaria Chemoprevention an operational paradigm: A mathematical modelling approach.

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Abstract

Seasonal malaria chemoprevention, or SMC, is a crucial intervention for managing malaria in areas with high malaria transmission, particularly in young children. This study employs a mathematical model to explore the operational procedures of SMC with the goal of lowering infections in high transmission settings to levels associated with moderate transmission and ultimately moving from moderate transmission to pre-elimination. The model takes into account a number of important variables that impact the intervention's efficacy, such as the number of doses given each season, coverage rates, and the timing of SMC administration.

In this study, we examined the effects of varying SMC campaign start times, coverage levels, and dosage administration rates on the dynamics of malaria transmission and, ultimately, malaria incidence. The mathematical model developed was used to determine the optimal combinations for reducing the incidence of malaria through the adjustment of these different operational procedures.

Additionally, we analysed the transition from moderate transmission to pre-elimination, identifying important factors that will help achieve this transition. The results suggest that optimizing the timing and dosage of SMC, along with maximizing coverage, can have a substantial impact on the control and elimination of malaria.

Keywords: malaria, chemoprevention, coverage, timing, dosage

Category: **Mathematical Biology**

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Targeting Melanoma: Predictive Mathematical Models with the Potential to Transform Cancer Treatment[1]

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[1]This project was funded by the GES4.0 funding from the University of Johannesburg

Abstract

Melanoma, the most aggressive form of skin cancer, poses significant challenges for treatment due to its high potential for metastasis and resistance to conventional therapies. Recent advances in predictive mathematical modeling offer new approaches to streamline drug discovery and development for melanoma by enabling the identification of promising therapeutic compounds before laboratory testing. This presentation outlines a framework for predictive mathematical models designed to identify and prioritize candidate compounds targeting key molecular pathways involved in melanoma progression. Specifically, we utilize machine learning tools to build models that help in identifying compounds that treat melanoma. By combining in silico screening with machine learning algorithms, these models not only predict compound efficacy but also suggest optimal dosing and combination strategies to maximize therapeutic outcomes. The ultimate goal is to create a seamless pipeline from computational predictions to laboratory validation, facilitating faster, cost-effective discovery of novel treatments for melanoma. Our findings demonstrate that predictive modeling is a valuable tool in narrowing down drug candidates, enabling targeted laboratory testing, and advancing personalized treatment strategies for melanoma.

Keywords: Cancer, Melanoma, Predictive models, Machine learning, Algorithms

Category: **Mathematical Biology**

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Spatial patterns in microbial communities within hostile environments.

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Abstract

Microbial communities in natural environments typically adapt in response to changes in both internal and external conditions. External conditions may include the availability or depletion of growth-limiting nutrients, and the presence of inhibiting or toxic substances while internal conditions may include cell-to-cell interactions. We present and investigate a spatiotemporal bacterioplankton-chemorepellent interaction model considering the quiescent stage and microbial movement in response to their environment. We establish conditions under which microbial population oscillations (boom-and-bust) may occur. Bifurcation analysis of the proposed models is presented and the interplay between Turing and Hopf instability will be discussed. Numerical simulations supporting the existence of stable spatial patterns as well as oscillatory patterns will be presented.

Keywords: Stationary patterns; Oscillatory patterns; Microbial population; Environmental stress.

Category: **Mathematical Biology**

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Modeling and Control of Unemployment Dynamics.

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Abstract

This work examines the use of compartmental modelling and optimal control theory to analyse and manage unemployment dynamics. The workforce is split into four categories: employed, unemployed active, unemployed passive, and removed from labour force. The transitions between these states are governed by parameters reflecting job finding rates and job separation rates. Optimal control theory is employed to determine the best strategies for minimizing unemployment levels and associated social costs. Control variables include policies such as job

creation programs, unemployment benefits, and training initiatives. The objective is to minimize a cost functional representing both the economic costs of unemployment and the costs of implementing control measures over a specified time horizon. Insights into the effectiveness of different policy interventions and the trade-offs involved are revealed. By simulating various scenarios, the model helps policymakers identify optimal strategies under different economic conditions and constraints. The relative costs and outcomes of the different interventions are evaluated to efficiently allocate resources. This approach provides a framework for making informed decisions to stabilize and reduce unemployment, ultimately contributing to more resilient and dynamic labour markets.

Keywords: compartmental modeling, optimal control, unemployment dynamics, labor market policies, cost effectiveness

Category: **Mathematical Modeling**

References

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Magnetohydrodynamics Williamson nanofluid flow over a stretching surface with chemical reaction and thermal radiation.

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Abstract

Presented in this current study is the numerical analysis of magnetohydrodynamics Williamson nanofluid flow over an exponentially stretching surface. The most important aspect of the investigation is that the effects of the magnetic field, chemical reaction and thermal radiation in the fluid flow are taken into account. The partial differential equations governing the present Williamson nanofluid flow problem were observed to be highly nonlinear and coupled. Suitable similarity transformations were used to transmute the coupled system of nonlinear partial differential equations governing the fluid flow into a linear system. The linear system was solved numerically using the Spectral Quasi-Linearization Method. The MATLAB bvp4c numerical technique and a comparison with existing results for the skin friction coefficient were used to confirm the appro priateness of the method in solving the current problem. The influence of some pertinent physical parameters on the fluids velocity, temperature and concentration profiles were displayed graph ically. The effects of all the physical parameters on the skin friction coefficient, Nusselt number and Sherwood number were portrayed in a tabular form. It was

noted that enhancing the thermal radiation parameter reduces the fluids temperature, Nusselt number and the skin friction coefficient whilst the Sherwood number is improved.

Keywords: Magnetohydrodynamics, Williamson nanofluid, quasi-linearization, chemical reaction, thermal radiation

Category: **Fluid Dynamics**

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New Solutions of PDEs Derived from Nonclassical Invariant Solutions via Classical Point Symmetries.

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Abstract

Lie symmetry analysis is a powerful method for obtaining exact solutions of partial differential equations (PDEs). Both classical and nonclassical symmetries provide systematic approaches to constructing invariant solutions. In addition, classical point transformations can be applied to nonclassical invariant solutions to generate new solutions. This study focuses on identifying the classical and nonclassical symmetries of selected PDEs. We demonstrate how point symmetries of the equations can be used to map nonclassical solutions into new, exact solutions, enriching the solution space of the original PDEs.

Keywords: Lie symmetry analysis; classical symmetries; Nonclassical symmetries; Invariant solutions; Optimal system.

Category: **Computational Mathematics**

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Performance Prediction for a University Programming Course Using Learning Management System Data

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Abstract

This paper addresses the problem of predicting student performance for a first year university programming course at the University of Botswana. Students used the Moodle Learning Management System to access course material and submit assessments, including assignments and quizzes. They also attended lectures and labs. We train a logistic regression model to make predictions regarding whether a student passed or failed the course. There were 244 students registered in the offering, with the data set having 35 features, which included engagement with several quizzes, several lab exercises, source code, a number of lecture slides, and material from prior offerings of the same course. Evaluation was carried out using significance levels (p-values). Our results indicate that the main features that affected passing or failing of the course were engagement on the Moodle Learning Management System with practice software that the lecturer made available (statistically significant at the $p < 0.01$ level), engagement with early lab sessions (statistically significant at the $p < 0.01$ level), and engagement with material from prior offerings of the course (statistically significant at the $p < 0.01$ level). The information obtained from statistical analysis could enable the course coordinators to monitor performance in the identified components of the course and take preventive measures in order to reduce failure rate.

Keywords: Machine Learning, Educational Data Mining, Tertiary Education

Category: **Data Science**

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Solving the Lane-Emden Equation Using Physics-Informed Neural Networks (PINNs)

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Abstract

The Lane-Emden equation, a nonlinear second-order ordinary differential equation, plays a central role in theoretical physics and astrophysics, particularly in modeling the structure of stellar interiors. Also known as the polytropic differential equation, it describes the behavior of self-gravitating polytropic spheres. In this paper, we present a novel approach to solving the Lane-Emden equation for $n = 0$ using Physics-Informed Neural Networks (PINNs). PINNs integrate neural networks with the governing physical laws by embedding the differential equation directly into the training process. This approach offers a flexible and data-efficient method for solving differential equations, even in cases where traditional numerical methods may struggle.

We experimented with five different optimization algorithms to train the PINNs and found that the Adam optimizer delivered the best performance, followed closely by RMSprop. Furthermore, we assessed the impact of six distinct activation functions on the quality of the solutions produced by the neural network. The `tanh`, `silu`, and `swish` activation functions emerged as the most effective in generating accurate solutions. Our results demonstrate the potential of PINNs as a powerful tool for solving the Lane-Emden equation, with certain optimizers and activation functions yielding superior outcomes.

Keywords: Lane Emden Equation, PINNs, Neural Network, Differential Equation, Optimization Algorithms

Category: **Data Science**

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Symmetry Reductions of the $(1+1)$-Dimensional Broer-Kaup System Using the Generalized Double Reduction Method.

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Abstract

The generalized theory of the double reduction of systems of partial differential equations (PDEs) based on the association of conservation laws with Lie-Bcklund symmetries is one of the most effective algorithms for performing symmetry reductions of PDEs. In this article, we apply the theory to a $(1+1)$-dimensional Broer-Kaup (BK) system, which is a pair of nonlinear PDEs that arise in the modeling of the propagation of long waves in shallow water. We find symmetries and construct six local conservation laws of the BK system arising from low-order multipliers. We establish associations between the Lie point symmetries and conservation laws and exploit the association to perform double reductions of the system, reducing it to first-order ordinary differential equations or algebraic equations. This talk contributes to the broader understanding and application of the generalized double reduction method in the analysis of nonlinear PDEs.

Keywords: double reduction; Broer-Kaup System; lie symmetry analysis; conservation law; nonlinear PDEs.

Category: **Computational Mathematics**

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Lie symmetry analysis; Differential equations; Symmetry group; Algorithmic solution methods.

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Abstract

Lie symmetry analysis offers a powerful, structured framework for studying differential equations. This presentation highlights both the aesthetic elegance and algorithmic nature of Lie symmetry techniques. Through illustrative examples, the talk demonstrates how symmetries streamline solution methods for studying and finding solutions of ordinary and partial differential equations. Particular attention is given to how these routines form repeatable, algorithmic steps. This exploration highlights the role of Lie symmetry analysis as a practical tool for studying differential equations.

Keywords: Lie symmetry analysis; Differential equations; Symmetry group; Algorithmic solution methods.

Category: **Computational Mathematics**

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A new flexible generalized family for generating continuous models.

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Abstract

The article introduces the Marshall-Olkin alpha log-power transformed G family, a new generalization of the alpha log-power transformation, aimed at addressing the limitations of classical statistical models in accurately representing real-life datasets. This new family of distributions offers greater flexibility and is structured to handle diverse data patterns, including non-monotonic hazard rate functions. Some structural aspects of the new model are discussed in this article. The parameters of the new model are estimated using the maximum likelihood estimation method. The article examines specific instances of the new family, showing its versatility in handling different types of data distributions. Through a simulation exercise with varying sample sizes, the performance of the proposed estimation method is assessed. The new model is applied to both right skewed and moderately left-skewed datasets. The results show that it provided a better fit and more accurate representation of the data, as compared to other models considered in this research.

Keywords: Marshall-Olkin-G; Exponentiated-G; Quantile Function; Hazard Rate Function; Order Statistic; Shannon Entropy; Monte Carlo Simulation.

Category: **Data Science**

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Stability results for a sequence of Gornicki type contraction mappings.

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Abstract

This paper examines the stability of fixed points for a sequence of mappings (T_n) in a metric space (X, d), where each mapping is defined on a subset X_n of X. The stability of fixed points of contraction mappings has been studied by Bonsall [5] and Nadler [21]. They studied the convergence of fixed points for a sequence of maps (T_n) defined on a metric space (X, d) under pointwise or uniform convergence, under contraction assumptions of the maps. However, if the domain of definition of (T_n) is different for each $n \in N$, then these notions do not work. Barbet and Nachi [4] addressed this issue by introducing some new notions of convergence and obtained stability results in a metric space which generalize the earlier results of Bonsall [5] and Nadler [21]. In this paper, the stability of fixed points for a sequence of mappings (T_n) that satisfy the contraction conditions introduced by Gornicki [11] is studied in a metric space (X, d). We focus on two types of convergence, G-convergence and H-convergence, and demonstrate the applicability of our findings to an initial value problem for an ordinary differential equation.

Keywords: Stability, G-convergence, H-convergence, Gornicki contraction mapping

Category: **Data Science**

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Numerical optimal control approach for a hyperbolic system of conservation laws.

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Abstract

In this presentation, we focus on the optimal control of a hyperbolic system of conservation laws. These systems model the flow of inviscid gas, shallow water to name two examples. The idea is to determine an initial profile in order to attain a desirable state of the flow. A partial differential equations constrained problem is posed and simulated. To discretise the system, a finite volume approach is applied. Further a networked flow domain will be considered. Some issues that may pose as challenges as well as opportunities will be highlighted. Computational results of the optimal control approach will be presented and discussed.

Keywords: Optimal control, numerical analysis, hyperbolic system of conservation laws

Category: **Computational Mathematics**

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Demonstrating the Capabilities of ChatGPT o1-Preview in Extending Block Hybrid Methods to Higher-Order Boundary Value Problems.

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Abstract

This study highlights the capabilities of the ChatGPT o1-Preview model in extending block hybrid methods, a class of implicit Runge-Kutta methods, from second-order to third-order, fourth-order, and fifth-order boundary value problems (BVPs). Leveraging the advanced computational abilities of the ChatGPT o1-Preview model, we develop new formulations tailored for higher-order differential equations and implement efficient computational algorithms. The model assists in identifying optimal collocation points to enhance the accuracy of the solutions. Comprehensive stability, error, and convergence analyses are conducted with the support of ChatGPT o1-Preview, establishing the theoretical foundations of the proposed methods. Autonomous numerical experiments are performed to evaluate performance, demonstrating the effectiveness and reliability of both the extended methods and the AI model. The results underscore the potential of utilizing ChatGPT o1-Preview in advancing numerical methods for solving higher-order BVPs in scientific and engineering applications.

Keywords: Block hybrid methods, Boundary value problems, Higher-order differential equations, Generative AI, ChatGPT o1-Preview

Category: **Computational Mathematics**

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Hydraulic fracturing with fluid leak-off: Mathematical models and solutions.

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Abstract

Hydraulic fracturing is a well stimulation technique used in order to improve the productivity of crude oil and natural gas from underground reservoirs. The technique involves injecting fluid at ultra-high pressure into the reservoir rock in order to propagate pre-existing fracture networks or create new fractures. A crucial goal in hydraulic fracturing is the use of the high pressure fluid to continually create and propagate new fractures in the rock formation, in order to continually liberate the crude oil and natural gas that may have been trapped. However, because of the permeable nature of the rock formations, fluid leak-off into the formations do occur, the rate of which increases as more and more fractures are created. The effect of fluid leak-off on fracture extension or propagation is significant and several research in this area has been done. In this talk, a mathematical model for the propagation of a pre-existing hydraulic fracture with fluid leak-off in a permeable rock will be presented. The empirical Darcy law is used to describe the fluid leak-off through the permeable fracture interface into the rock formation. The fluid flow in the fracture is laminar and the fracture is driven by a viscous incompressible Newtonian fluid. When lubrication theory is applied to the fracturing fluid flow in the hydraulic fracture, a system of integro-differential equations for the fracture half-width and the leak-off depth is obtained. Similarity and numerical solutions obtained for the integro-differential system are presented.

Category: **Computational mathematics**

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Lie group methods for solving reaction-diffusion equations.

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Abstract

Reaction-diffusion equations describe how chemicals react and how diseases spread but solving them can be challenging in complex situations. Lie group analysis, a method that utilizes symmetries in equations, has shown potential for enhancing the speed and accuracy of solutions. How ever, this approach has primarily been tested on simple or ideal cases, with limited application to more complex, real-world problems. This gap indicates that the full potential of Lie group methods is not being fully realized, especially in complicated reaction-diffusion systems with nonlinear behaviours and challenging boundary conditions. The present work aims to expand the use of Lie group methods to solve somereaction-diffusion problems, test their effectiveness, and demonstrate how they can be applied in practical scenarios.

Keywords: Lie symmetry, Reaction-diffusion equations, Infinitesimal generator, Lie group of point transformations

Category: **Data Science**

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UNDERSTANDING THE DIVERSE FAMILIES OF NAMIBIA: AN APPLICATION OF A GROWTH CURVE MODEL OF THE STRUCTURAL EQUATION MODELS.

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Abstract

This study seeks to understand the diverse families in Namibia and their contributions to well-being of the children and country demographics. According to Riggs, attitudes towards family diversity continue to improve over time (Riggs, 2018). Understanding the diversity of families in which children are raised can improve theory and research on parenting (Pearce, 2018). Globally, over the years, demographic trends have transitioned and resulted into diverse sets of family structures, giving rise in interest to explore diverse family structures as key developmental contexts for adults and children. This study is based on four primary domains: approaches to measuring family structure, approaches to analysing associations between family structure and well-being, the application of theory, and conceptualizations of well-being (Jensen, 2021). This is a cross-sectional study that uses the NIDS 2016 dataset, with 624 Primary Sampling Units from which 12480 households, and 47345 individual responses. Structural Equation Modelling (SEM) approach is used in examining the validity of theories with empirical data based on covariance and variance (Ringle, 2010). The SEM takes form of $\eta = B\eta + \Gamma\xi$, the measurement model for y is given by: $y = \wedge_y \eta + \xi$ and the measurement model for x is given by: $x = \wedge x\xi + \delta$. There will be covariance and variance model comparisons using DIC, AIC and BIC values. The data will be analyzed using different software including R-Studio, Microsoft Excel, SPSS and/or STATA where applicable.

Keywords: Family, Family-Diversity, SEM, Well-being, Demographics, R-Studio, SPSS.

Category: **Data Science**

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Statistics of extremes with applications to financial markets and wind speed data.

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Abstract

Modelling the extremes of financial stock returns and losses is vital to economic survival. Similarly, modelling wind speed is vital to wind power energy generation. However, with limited amount of information it can be difficult to estimate the parameters of the distributions due to the enormous variance and heavy tails of the financial markets and wind speed data. The problem of limited amount of information has inspired the present study to examine and model the extreme value behaviour of the Johannesburg Stock Exchange (JSE) financial market data using the extreme value theory. The study utilised the secondary wind speed data as well as the JSE financial markets data in South Africa, which comprise the daily All-Share Total Return Index (ALSTRI) and the daily the US dollar against the South African rand (USD/ZAR) exchange rate. The generalised extreme value distribution (GEVD), r-largest order statistics GEVD (GEVDr), generalised Pareto distribution (GPD), and the newly proposed blended GEVD (bGEVD) models were applied to the five-year daily JSE financial market data. The 100-year return levels of the monthly block maxima models were almost equal to the maximum observations of the financial markets of 10860 and R18.99 for the ALSTRI and the USD/ZAR respectively, while the peak-over-threshold return levels were comparatively higher than the block maxima return levels for all the financial markets. As for the wind speed, the (GEVDr) method was used and the short-term results were found to be very comparable with the machine learning results.

Keywords: Generalised extreme value distribution, machine learning, return levels, r-largest order statistics.

Category: **Data Science**

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Statistical Analysis of the Stationarity, Normality, and Independence of Selected Securities on the Namibian Stock Exchange: A Daily Time Frame Study

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Abstract

This study investigated the statistical properties stationarity, normality, and independence of the four securities namely, ANM, OCG, FNB and SRH listed on the Namibian Stock Exchange (NSX) using the Augmented Dickey-Fuller test for stationarity, the Shapiro-Wilk test for normality and the Ljung-Box test for independence. The assumptions are necessary because they establish the random walk or white noise behaviours equivalent to the Brownian motion process which is commonly used in financial and economic data analysis. The results show that all the securities were stationary, but normality was not met probably because of the time frame used in the study. Normality may be better fulfilled by the shorter timeframes such as the 1-hour or 4-hour data. Independence was confirmed for ANM and SRH but was rejected for OCG and FNB. The employment of the Hurst exponent brought out different degrees of predictability, as for instance ANM showed weak persistence, OCG demonstrated strong mean-reverting tendencies, while FNB and SRH showed more complex behaviours fluctuating between short-term trend and mean reversion. These results underscored that this study was not just about testing hypotheses. Through demonstrating the correlation between the statistical properties and Brownian motion, the research provides practical information surrounding the predictability and market dynamics of NSX securities that is of the utmost importance for investors and decision makers in the financial sector in Namibia.

Category: **Statistics**

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Patterns, Prevalence and Determinants of Low Birth Weight among Newborns in Namibia: Evidence from the 2013 NDHS

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Abstract

Low birth weight (LBW), defined by the WHO as a weight at birth of less than 2.5kg, is influenced by various factors. Infant weight at birth is widely accepted as the single most important determinant of perinatal survival and poor infant development (Lui et al., 2023). This study aimed to examine the relationship between socio-economic status and birth weight by analyzing birth weight patterns, bivariate associations, and factors influencing birth weight in Namibian newborns. The causes of birth weight, which were classified as "small to very small" to "large to very large," were examined in this quantitative study using a sample of 1,200 infants with recorded birth weights from the 2013 NDHS using ordinal regression. It was necessary to employ a partial proportional odds model since the partial proportional odds assumption was violated. The findings of the partial proportional model revealed a noteworthy inverse relationship between smoking ($p = 0.005$) and birth weight as well as a substantial positive link with wealth($p < 0.001$). Ultimately while maternal behaviors like smoking showed a negative impact on birth weight, socioeconomic status had a direct positive relationship with it. Factors like maternal age, job type, education, and alcohol consumption did not significantly affect birth weight.

Keywords: Birth weight; Socioeconomic status; NDHS; regression; Namibia

Category: **Statistics**

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Predictability and Prevalence of Tuberculosis (TB) Diagnosis Using Machine Learning Approaches in Namibian Public Hospitals.

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Abstract

Integrating AI models with health applications can tremendously assist health professionals and policymakers in disease diagnosis, personalized treatment, smart care and evidence-based decision-making. The objective of the study was to estimate the prevalence of TB, identify the predictors TB; and explore the predictive ability machine learning models in TB diagnosis. The sample of 57 was based on secondary data from Windhoek Central Hospital and Oshakati Intermediate Hospital on visit date, age, sex, history of present illness, chief complaint, Imaging Chest (CT) result, disease history, smoking status, allergy history, physical examination result, and TB result. TB diagnosis was primary outcome variable. Descriptive statistics were used to profile the background characteristics of the sample. Bivariate tests of association and machine learning classification models (Random forest, Decision tree, Nave Bayes and K-Nearest Neighbour KNN) were explored to predict TB diagnosis in Namibian hospitals. Model performance was based on sensitivity, specificity, precision, accuracy, F-score, AUROC curve and variable importance to select the best model. Results suggested that the Random Forest was

the best model to predict TB diagnosis with an average accuracy of 68.3% compared to KNN (66.7%), Decision Tree model (63.3%) and Nave Bayes model (61%). Important variables for TB diagnosis were imaging chest (CT), physical examination, chief complaint, smoking history, and sex.

Category: **Statistics**

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Trends And Factors Associated with Non- Condom Use Among Youths in Botswana.

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Abstract

Background: Despite significant progress in HIV prevention and treatment in Botswana, inconsistent condom use among young people remains a pressing public health concern. This study aimed to investigate trends and associated factors influencing condom use among this vulnerable population.

Methods: Data from the Botswana AIDS Impact Surveys (BAIS-IV and BAIS-V) were analysed to examine non-condom use among young people aged 15-35 in Botswana. Descriptive statistics, bivariate, and multivariate logistic regression analyses were conducted to identify factors associated with non-condom use.

Results: Overall, there is a decrease in non-condom use from non-condom use among youths in Botswana from 35.3% in 2013 to 32.4% in 2021. Gender disparities persisted, with females reporting higher rates of non-condom use than males. Marital status was a significant factor, with married individuals less likely to use condoms compared to single or cohabiting individuals. Education level was also associated with condom use, with those with higher education more likely to use condoms. HIV positive and those who ever tested for HIV had their risk of not using a condom significantly reduced.

Conclusion: The risk of non-condom use remained high for female youths in Botswana. A positive gain in condom use is observed among the unemployed, rural, HIV positive, HIV ever tested youths, including youths with at least secondary education.

Keywords: Human Immune Virus, Youths, Non-Condom Use, Multivariate Logistic Regression

Category: **Statistics**

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Permutation one-sided multivariate test for categorical variables: a biomedical case study.

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Abstract

In this work, a permutation test for multivariate categorical response variables and directional alterative hypothesis is presented. The application consists in evaluating the effect of an advanced treatment, called assisted motor activity (AMA) on the health of patients affected by low back pain (LBP), hypertension and diabetes. Such a treatment is based on specific physical exercises aimed at restoring motor limitations caused by various factors. Specifically, the goal is to test whether AMA determines an improvement in the functionality and perceived health status of comorbid patients represented by a multidimensional outcome.

Keywords: Biostatistics, Categorical data, Directional alternative, Multivariate, Permutation test

Category: **Statistics**

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Stochastic optimal control of a domestic islandic Microgrid management system equipped with solar panel, battery storage and a generator.

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Abstract

Although Namibia has made tremendous progress in controlling the HIV epidemic, new infections are still higher than deaths. This study examined the impact of marital status among HIV-positive individuals in Namibia. Descriptive statistics were performed in the form of figures and tables to explore the demographic characteristics of the individuals. Survival analysis techniques(Kaplan-Meier to construct the survival curves, Log-Rank Test to determine differences in survival between groups, and Cox Proportional Hazard to investigate the association between the survival time of the individuals and their demographic characteristics) were used to estimate the survival rate of the HIV-positive individuals. The study reveals a higher HIV prevalence among females (64.4%) compared to males (35.6%), with the age group 34 44 years being the most affected group. Khomas, Ohangwena, and Zambezi regions had the highest percentage of reported HIV-positive cases. According to the Cox Proportional Hazard model showed that the survival rate of HIV prevalence was influenced by marital status, region, WHO stage, viral load, and weight category. At the same time, age, gender, and CD4 counts were not statistically significant. Those who were widowed, cohabiting or divorced had a higher risk of death compared to married individuals. The Weibull distribution flexibility was the best fit for modeling the hazard function in this study. The research study recommends that there is a need for a greater focus on high-prevalence regions and among high-risk groups, particularly divorced individuals.

Keywords: HIV, marital status, Weibull distribution, Kaplan Meier, Cox Proportional Hazard

Category: **Statistics**

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DEVELOPMENT OF AN AI-ASSISTED WEB APPLICATION FOR DETECTING AND CLASSIFYING BRAIN TUMOURS IN SCANNED IMAGES.

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Abstract

With more than 120 recognised classifications for brain tumours, the complexity and wide range of forms are considerable challenges in medical diagnostics. Due to the complexity involved,

manual identification of tumours and their classification in images obtained from MRI and CT scans are highly time-consuming and prone to errors that lead to false positives and negatives. Such will delay treatment and increase costs in medicine. Even now, when development in artificial intelligence is advanced, many high-quality diagnostic algorithms remain locked on technical platforms. Therefore, they are unavailable for some specialists and even many medical specialists. This research aimed to overcome these problems by developing an accessible and reliable brain tumour detection system as a web application that is accessible without any need for download or complex installation. Downloading is an option that is convenient for the user. The main aim of this project was to develop an AI-assisted web application for detecting and classifying brain tumours in scanned images. An AI system such as this will go a long way in improving the rate of positive patient outcomes since it allows for earlier identification and intervention of medical issues. This project also aims to bridge this critical gap between highly complex Machine Learning models and practical clinical applications to improve the accessibility and accuracy of brain tumour diagnoses, leading to superior patient care and improved patient outcomes. The most critical phases of this study were the collection of data, engineering and evaluation of the model and deployment. Data preparation included the collection of data. Model engineering includes the training of CNNs that can detect, classify, and grade tumours of the brain with great precision. Performance was then evaluated at length using statistical methods like the confusion matrix evaluation and precision-recall analysis. Finally, the models were deployed to APIs and integrated into a user-friendly web app, making the model accessible to healthcare professionals.

The result of the study proved that Medalgo (Name given to this researchs app) efficiently detected and classified brain tumours, satisfying the critical need for diagnosis in medicine. The YOLOv10-driven model of detection and classification models of tumour type and grade have produced highly accurate results; most users rated the system high because they believe it reduces errors in diagnosis. The user's feedback valued the power of the application for diagnosis simplification. At the same time, areas of improvement included more user-friendliness, increased processing speed for large files, and added detection capabilities regarding tumours. Generally, Medalgo was well-appreciated for its ease of access, precision, and potential to promote diagnostic workflows; thus, it provided a sound basis for further improvement and broader applicability.

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Multilevel Analysis of the Ideal Number of Children among Namibian Women.

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Abstract

This study investigates the factors influencing the ideal number of children among Namibian women, focusing on individual and regional differences using a Poisson regression model within a multilevel framework. Using data from Namibia Demographic and Health Survey (NDHS),

the research explore how factors such as age, type of residence, education level, marital status, wealth index, and husband's desire for children impact reproductive preferences. These variables allow for a nuanced understanding of fertility preferences at both the individual and regional levels, given the hierarchical nature of the data where women are nested within regions. Preliminary results indicate that socioeconomic and cultural factors significantly influence the ideal number of children, with notable variations across regions. Early findings suggest that women in urban areas have a lower ideal number of children compared to their rural counterparts, reflecting differences in access to education, healthcare, and employment opportunities. Additionally, the influence of the husband's desire for children emerges as a critical factor, particularly in regions where traditional gender norms remain strong. This research contributes to a deeper understanding of reproductive behavior in Namibia and offers insights for policymakers aiming to address regional disparities in fertility outcomes. Additionally, it contributes to the growing body of literature on fertility preferences in sub-Saharan Africa and offers policymakers in Namibia data-driven guidance to support targeted interventions that consider both individual-level needs and broader regional differences. **Keywords:** Ideal number of children,

Namibian women, Reproductive preferences, Poisson regression, Multilevel analysis.

Category: **Statistics**

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A COMPARATIVE ANALYSIS OF STUDENTS, ACADEMIC PERFORMANCE BASED ON GENDER DIFFERENCES FOR FIRST-YEAR INTRODUCTION TO STATISTICS MODULE AT THE UNIVERSITY OF NAMIBIA MAIN CAMPUS FROM 2018-2022.

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Abstract

This study investigated the academic performance of male and female students enrolled in the University of Namibia (UNAM) Main Campus's first-year Introduction to Statistics module from 2018-2022. The data was sourced from the Directorate of Institutional Research & Business Intelligence at UNAM. A quantitative research design was used to analyse final, continuous assessment (CA), examination marks, age, gender, residence and qualification name using multiple linear regression and t-tests. The study found that the overall academic performance was similar for male and female students, indicating that gender did not consistently affect performance. On the other hand, there was one instance in 2019 where female students performed better than male students, suggesting that gender-related performance differences could be influenced by external factors. The study also discovered that other factors, such as age, did impact performance, with older students performing slightly worse, while residency status and qualification name showed no significant effect. The study recommends maintaining a gender-neutral approach to academic support while regularly monitoring performance data for

emerging differences. Providing flexible learning resources and targeted interventions based on student needs may assist students achieve greater academic success. To better understand the factors influencing student performance, additional research should include variables such as study habits, socioeconomic status, and external challenges. By implementing the recommended measures mentioned above, the University of Namibia can maintain an inclusive and equitable learning environment that encourages academic success for all students, regardless of gender or other demographic factors.

Keywords: Academic performance, gender, female students, male students, Introduction to Statistics, University of Namibia.

Category: **Statistics**

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AN APPLICATION OF SURVIVAL ANALYSIS AND RISK FACTORS FOR DEATH IN TUBERCULOSIS PATIENTS ON DIRECT OBSERVED TREATMENT IN NAMIBIA.

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Abstract

Tuberculosis (TB) is a contagious infection that usually attacks your lungs. It can also spread to other parts of the body, like the brain and spine. A type of bacteria called Mycobacterium tuberculosis causes it. the country reported 9,200 TB patients, marking an increase from 8,604 TB patients cases representing a 6.9% rise. For this reason, this study will identify the risk factors associated with mortality in TB patients which will allow for planning effective interventions to further reduce death rates. The main objective of the study is to apply survival analysis and identify risk factors for death in tuberculosis patients on direct observed treatment in Namibia. Tuberculosis unit (TU) at clinics and hospitals, within the Republic of Namibia. This study follows a retrospective quantitative research design method. Data of patients registered for DOTS in the year January 2019 to December 2023 is collected from the Ministry of health and social services (MoHSS) tuberculosis register. KaplanMeier (KM) method and log-rank tests is to compare survival curves. A Cox proportional hazards regression model will be used to determine factors associated with the risk of death in TB patients.

Keywords: Tuberculosis, mortality.

Category: **Statistics**

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PATTERNS IN AGE AT FIRST MARRIAGE AMONG WOMEN AND ITS DETERMINANTS IN NAMIBIA: A HISTORICAL PERSPECTIVE OF NAMIBIA DEMOGRAPHIC AND HEALTH SURVEY (1992 - 2013).

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Abstract

Patterns and trends in the age at first marriage are important social indicators, reflecting broader socio-economic and cultural dynamics. Early marriage for young women may lead to low educational attainment, and increased fertility span resulting in early pregnancy which may increase the population growth rapidly and poor health outcomes. This research investigates the trends and patterns in the age at first marriage among Namibian women and socio-economic and cultural determinants, using the Namibia Demographic and Health Survey (NDHS) data from 1992 to 2013.

The findings revealed that educational attainment, wealth index, region, and religion significantly influence marriage timing. The mean age at first marriage was 21.3, 22.5, and 21.9 years in 1992, 2006, and 2013 respectively. Educational attainment was a significant predictor of delayed marriage, where women with higher levels of education got married later. Urbanization and economic prosperity also delayed marriage, particularly in wealthier regions like Khomas. Similarly, poorer women and women living in rural areas had earlier marriages driven by economic pressures and limited opportunities. The Cox Proportional Hazard Model and Kaplan-Meier curves showed regional, socio-economic, and religious disparities whereby the Protestant/Anglican women got married later than Roman Catholic women. The study recommends access to education for girls be expanded, particularly in rural areas, and promoting economic empowerment programs to improve womens socio-economic status. In addition, research into the cultural and religious drivers of marriage timing and the exploration of time-varying effects in the determinants of marriage should be carried.

Keywords: age at the first marriage, Namibian women, socio-economic determinants, early marriage, NDHS.

Category: **Statistics**

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Trend and Epidemiological Analysis of Coronavirus in Namibia.

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Abstract

This study provides a comprehensive epidemiological and trend analysis of COVID-19 in Namibia from March 2020 to May 2023, aiming to understand the spread, impact, and key drivers of the pandemic within the country. Using data from the Ministry of Health and Social Services, the research explored key epidemiological measures, including Case Fatality Rate (CFR), Infection Fatality Rate (IFR), Mortality Rate (MR), and Incidence Rate (IR). It also assessed the impact of comorbidities on COVID-19 outcomes and employed a multivariate time series analysis to understand the dynamics between COVID-19 cases, deaths, and recoveries. Additionally, a descriptive analysis was conducted on COVID-19 cases, recoveries, and deaths by gender, age, and region. The analysis revealed significant gender and age-related disparities, with males showing higher fatality rates and older age groups (particularly those aged 60 and above) experiencing more severe outcomes. Regional trends showed that Erongo and Khomas had the highest mean case numbers, with 1,521.77 and 1,278.97 respectively, while Kavango West had the lowest mean at 23.72. In terms of fatalities, Khomas recorded the highest mean deaths at 20.26, while Kavango West had the lowest at 0.54, highlighting substantial regional disparities in both cases and mortality.

The national average CFR was 1.2031%, with Omaheke recording the highest rate at 2.9746% and Khomas the lowest at 0.7093%. The IFR ranged from 5.7773% in Omaheke to 1.4085% in Khomas, with a national average of 2.3776%. The MR averaged 0.00163 nationally, with the highest in Omaheke (0.00425) and the lowest in Kavango West (0.00025). The IR was highest in //Kharas at 0.119 and lowest in Kavango West at 0.009.

The study also found that individuals with pre-existing conditions faced a significantly higher risk of death, with a risk ratio of 3.012. A multivariate time series analysis using Vector Autoregression (VAR) showed that previous deaths had a positive influence on current case numbers, indicating a persistent pattern in the pandemic's progression. The model explained 76% of the variation in current cases, with Impulse Response Function (IRF) analysis demonstrating that shocks from deaths had a stabilizing effect on future case and recovery trends.

This research provides critical insights for Namibias public health strategies, offering evidence-based guidance to better target interventions by gender, age, and region, and to strengthen preparedness for future pandemics.

Keywords: COVID-19, Namibia, Epidemiology, Comorbidity, Time Series.

Category: **Statistics**

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GEOSPATIAL ANALYSIS OF THE DETERMINANTS INFLUENCING MORTALITY RATE IN NAMIBIA.

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Abstract

Improving population health is a key priority for many developing countries, particularly as they work to meet challenges like the Millennium Development Goals (MDGs). In Namibia, significant efforts have been made to reduce mortality; however, stark geographical disparities in mortality rates and their determinants remain evident across the country. This study aimed to identify high-risk areas for mortality and examine their determinants using geospatial analysis on 20162021 mortality data from the Ministry of Home Affairs and Immigration's civil registration system. A Poisson regression model was applied to assess mortality risk disparities across regions, sex, and age groups, while mortality hotspots were identified. Geographically Weighted Regression (GWR) was used to explore associations between mortality rates and determinants. The results show that the Khomas region has the highest relative mortality risk, followed by Oshakati, while Kavango West and Kunene exhibit significantly lower risks. This research underscores the need for region-specific public health interventions to address the factors driving mortality disparities, offering valuable insights for policymakers aiming to reduce mortality and improve health outcomes across Namibia.

The study also found that individuals with pre-existing conditions faced a significantly higher risk of death, with a risk ratio of 3.012. A multivariate time series analysis using Vector Autoregression (VAR) showed that previous deaths had a positive influence on current case numbers, indicating a persistent pattern in the pandemic's progression. The model explained 76% of the variation in current cases, with Impulse Response Function (IRF) analysis demonstrating that shocks from deaths had a stabilizing effect on future case and recovery trends.

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