İZMİR UNIVERSITY
OF ECONOMICS
PRESS

I. Workshop on Applied Mathematics and Statistics

Abstract Book

WAMS 2025

Department of Mathematics
İzmir University of Economics

May 10, 2025

Publisher İzmir University of Economics

ISBN 978-625-6001-21-3

Contents

Welcome to WAMS 2025 1

Committees 2

Workshop Program 3

Invited Speakers 4
- Münevver TEZER SEZGİN 4
- İsmihan BAYRAMOĞLU 5

Oral Presentations 6
- Ömer AKGÜLLER 6
- Sıla Övgü KORKUT UYSAL 7
- Aykut ALKIN 8
- Sinem ARSLAN ÖLÇER 9
- Oktay KARABAĞ 10
- Tolga YAMUT 11
- Yusuf Can SEVİL 12
- Halis Can KOYUNCUOĞLU 13
- Tuğçe KATICAN KOYUNCUOĞLU 14
- Hikmet Burak ÖZCAN 15
- Derya ÖZDEMİR 16
- Sıla Selenay KOÇ 17
- Demet ERSOY ÖZDEK 18

Poster Presentations 19
- Ali OĞULYAYMIŞ 19
- Alican AKCA 20
- Arda ERÇAKIR 21
- Atahan TAŞKIN 22
- Can Ege TÜRE 23
- Ceren GİBYELİ 24
- Elif İlkin ERSOY 25
- Fatma Ebru ZOZUK 26
- Gulceren IŞIK 27
- Hümay Zehra ÖZER 28
- Hümay Zehra ÖZER 29
- Hüseyin Münir PİŞKİN 30
- Merve Sevim ÖZKAN 31
- Merve Sevim ÖZKAN 32

Mine Cansın GÜNAY 33
Mine Cansın GÜNAY 34
Öykü KARASU 35
Selin MAVİ 36
Serhat BALIK 37
Tuna KUTOĞLU 38
Yaren COŞKUNYÜREK 39
Yunus Emre DEMİRTAŞ 40
Yusuf EROL 41

İZMİR UNIVERSITY OF ECONOMICS PRESS

Welcome to WAMS 2025

I. Workshop on Applied Mathematics and Statistics, organized by the Department of Mathematics at İzmir University of Economics, aims to provide a strong academic platform for young researchers.

This event offers master's and doctoral students the opportunity to share their research, engage in interdisciplinary interactions, and establish academic collaborations, while also allowing undergraduate students to take their first steps into the academic world through poster presentations.

In this workshop, we feature invited talks, short presentations, and undergraduate poster sessions in the fields of Applied Mathematics and Statistics. You can find the abstracts of the talks and posters in the abstract book you have in hand.

Finally, we would like to thank the members of the Scientific Committee, Organizing Committee, as well as the administrative personnel and students who supported the organization, for their dedicated efforts in making this workshop possible.

İzmir University of Economics
Department of Mathematics

Publisher İzmir University of Economics

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

Scientific Committee

Organizing Committee

Publisher İzmir University of Economics

ISBN 978-625-6001-21-3

I. Workshop on Applied Mathematics and Statistics (WAMS)

Izmir University of Economics Department of Mathematics Workshop Program

May 10th 2025

09:00-9:45	*Registration / Coffee Break / Poster Presentations*
9:45-10:00	*Opening Ceremony*
	Chair: Sevin Gümgüm Turhan
10:00-10:50	**Invited Speaker: Münevver Tezer Sezgin**
10:50-11:10	*Ömer Akgüller : Discrete Geodesic Distribution on Skeleton Graphs for Identifying Topological and Geometric Similarities in 3D Point Clouds*
11:10-11:30	*Sıla Övgü Korkut Uysal : Towards a Stochastic Approach in Tumor Growth Modeling*
11:30-11:50	*Aykut Alkın : The initial-boundary value problem for the higher-order nonlinear Schrödinger equation on the half-line*
11:50-12:10	*Sinem Arslan Ölçer : DRBEM Solution of Singularly Perturbed Magnetohydrodynamic Duct Flow using Parallel Computing*
12:10-13:30	*Lunch Break*
	Chair: Gözde Yazgı Tütüncü
13:30-14:20	**Invited Speaker: Ismihan Bayramoğlu**
14:20-14:40	*Oktay Karabağ : Optimizing Production and Recycling Decisions for Make-to-Stock Hybrid Manufacturing Systems Using Real-Time Information on Products in Use*
14:40-15:00	*Tolga Yamut : Modified Vine Copula Classifiers With Application to Gene Expression Data*
15:00-15:20	*Yusuf Can Sevil : Classification of Returns in Crypto Market*
15:20-15:40	*Halis Can Koyuncuoğlu : Some Results on Linear Hilfer Fractional Difference Equations*
15:40-16:40	*Coffee Break / Poster Presentations*
	Chair: Cemal Murat Özkut
16:40-17:00	*Tuğçe Katıcan Koyuncuoğlu : Sheffer Stroke Hilbert Algebras Stabilizing by Ideals*
17:20-17.40	*Hikmet Burak Özcan : On Regularity of the Discrete Hardy–Littlewood Maximal Operator*
17:40-18:00	*Derya Özdemir : Stability Analysis Of Nonlinear Time-Varying Systems In Cascade*
18:00-18:20	*Sıla Selenay Koç : A Mass-Conservative Numerical Method For The Nonlinear Schrödinger Equation*
18:20-18:40	*Demet Ersoy Özdek : A Numerical Approach for the HIV Infection Model Involving Latently Infected Cells*
19.00	*Dinner/Nefes Restaurant*

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Numerical Solution of Linear Integral Equations

Münevver TEZER SEZGİN[1]
[1]*Middle East Technical University, Department of Mathematics, Ankara, Turkey*
munt@metu.edu.tr

Abstract:
We consider here linear integral equations in which functions to be determined appear under the integral sign. Many problems originating from real life applications give rise to integral equations. Some examples are going to be given from population dynamics and physics. Types of integral equations and their analytical solution procedures are briefly discussed. These are, Fredholm integral equation with separable kernels, Hilbert-Schmidt theory, the method of successive approximations. Specifically, the theoretical solution of Abel's integral equation is shown. Numerical methods are approximate methods reducing integral equations to the set of algebraic equations. Among these, quadrature schemes, method of undermined coefficients are given with applications. Lastly, the boundary integral equation for Laplace equation is obtained.

Keywords: Linear integral equations, Numerical solutions

1. Rahman, M. (2007). *Integral Equations and their Applications*, WIT Press.
2. Hildebrand, F. B. (1965). *Methods of Applied Mathematics*, Prentice Hall.
3. Keener, J. P. (1988). *Principles of Applied Mathematics: Transformations and Approximation*, Addison Wesley.
4. Partridge, P. W., Brebbia, C. A., & Wrobel, L. C. (1992). *The Dual Reciprocity Boundary Element Method*, Computational Mechanics Publications.

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Theory of ordering of multivariate random variables and the records of multivariate random sequences

Ismihan Bayramoglu[1]
[1]*Department of Mathematics, Izmir University of Economics, Izmir, Turkey*
ismihan.bayramoglu@ieu.edu.tr

Abstract:
For a sequence of independent and identically distributed random vectors, we consider the conditional ordering concerning the magnitudes of some continuous function defined on the support set and satisfying certain regularity conditions. We also consider the Progressive Type-II right censoring for multivariate observations using conditional ordering. The need for the conditional ordering of random vectors exists for example, in reliability analysis when a system has n independent components each consisting of p arbitrarily dependent and parallel connected elements. I will present some results related to the theory of multivariate ordering, Progressively Type-II ordering, and multivariate records. The concept of multivariate records will be also discussed. Some examples of applications in economy and reliability analysis will be provided.

Keywords: Order statistics, Progressive type II censored order statistics, Multivariate ordering, Ordered in a norm sense random vectors.

References

1. Bairamov, I. and Gebizlioglu, O.L. (1998) On the ordering of random vectors in a norm sense, Journal of Applied Statistical Science 6, 77–86

2. Bairamov, Progressive Type II censored order statistics for multivariate observations, Journal of Multivariate Analysis 97 (2006) 797–809.

3. Arnold B.C., Castillo E. and Sarabia J.M. (2009). Multivariate order statistics via multivariate concomitantsJournal of Multivariate Analysis, 100, 946-951.

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Discrete Geodesic Distribution on Skeleton Graphs for Identifying Topological and Geometric Similarities in 3D Point Clouds

Tolga Akdeniz[1], **Ömer Akgüller**[1], **Mehmet Ali Balcı**[1]

[1] *Department of Mathematics, Faculty of Science, Mugla Sitki Kocman University, Mugla, Turkey*

tolga.akdeniz@ogenci.mu.edu.tr, oakguller@mu.edu.tr, mehmetalibalci@mu.edu.tr

Abstract:

This study proposes a kernel-based approach to analyze random point clouds in three-dimensional space by examining their graph representations. Specifically, PointNet dataset is used as a benchmark, and two types of graphs—the Gabriel Graph and the Beta Skeleton (with β = 1.5)—are constructed from these data. Each graph's structure is captured via central and orbital geodesic distributions, reflecting the shortest-path distances from the most central and most peripheral nodes, respectively. The proposed kernel function computes the ratio of Wasserstein-1 distances between these geodesic distributions, thereby quantifying structural similarities and differences among the graphs.

Results are presented as kernel-based similarity matrices, revealing how each graph pair compares in terms of central and orbital distance distributions. Notably, some entries become infinite when orbital distributions are nearly identical, indicating a specific topological overlap at the graph peripheries. In contrast, smaller kernel values signify more uniform similarities across both central and orbital distributions. Overall, these findings demonstrate that the kernel function effectively captures both local and global structural variations in the point clouds, as reflected in their associated graphs. The presence of consistent yet distinct patterns in the similarity matrices underlines the kernel's ability to differentiate nuanced topological features. Consequently, this approach offers a robust and interpretable method for measuring graph-based similarities among 3D point clouds.

Keywords: Point Cloud Processing, Geometry Processing, Graph Kernels, Discrete Geodesics

References

1. Balcı, M.A., Akgüller, Ö., Batrancea, L.M., Gaban, L. (2023). Discrete Geodesic Distribution-Based Graph Kernel for 3D Point Clouds. *Sensors*, *23*(5), 2398.

2. Yu, S., Mehta, P.G. (2010). The Kullback–Leibler rate pseudo-metric for comparing dynamical systems. *IEEE Transactions on Automatic Control*, *55*(7), 1585-1598.

3. Filippone, M., Camastra, F., Masulli, F., Rovetta, S. (2008). A survey of kernel and spectral methods for clustering. *Pattern recognition*, *41*(1), 176-190.

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Towards a Stochastic Approach in Tumor Growth Modeling

Sıla Ovgu KORKUT[1,2], Utku ERDOGAN[3] and Yasemin Baspinar[2]
[1]*İzmir Katip Celebi University, Department of Engineering Sciences, Izmir, Turkey.*
[2]*Dokuz Eylül University, Department of Translational Oncology,Izmir, Turkey*
[3]*Eskişehir Technical University, Department of Mathematics,Eskisehir, Turkey.*
silaovgu.korkut@ikcu.edu.tr, utkuerdogan@eskisehir.edu.tr, ybaskin65@gmail.com

Abstract:
Cancer remains one of the leading causes of mortality worldwide. Developing accurate mathematical models is crucial for understanding the underlying biological mechanisms and formulating effective treatment strategies. This study presents a novel mathematical model that incorporates stochastic dynamics to more realistically capture biological processes. The proposed model is validated using a customized algorithm by comparing its results with established deterministic models of glioblastoma reported in the literature. The numerical solution of the model is based on a finite element method for spatial discretization and a semi-implicit Euler method for temporal integration. Additionally, the computational convergence of the algorithm is demonstrated. The analysis is further supported by visualizations illustrating the progression of tumor cells.

Keywords: Stochastic Differential Equation, Tumor Growth, Real-life application

References

1. Araujo, R. P., & McElwain, D. L. S. (2004). A history of the study of solid tumour growth: the contribution of mathematical modelling. *Bulletin of Mathematical Biology*, 66(5), 1039–1091.

2. Bose, T., & Trimper, S. (2009). Stochastic model for tumor growth with immunization. *Physical Review E*, 79(5), 051903.

3. Enderling, H., & Chaplain, M. A. J. (2014). Mathematical modeling of tumor growth and treatment. *Current Pharmaceutical Design*, 20(30), 4934–4940.

4. Liu, X., Li, Q., & Pan, J. (2018). Gauss–Hermite quadrature approximation for estimation in generalized linear mixed models. *Physica A: Statistical Mechanics and its Applications*, 500, 162–176.

5. Lord, G. J., Powell, C. E., & Shardlow, T. (2014). *An Introduction to Computational Stochastic PDEs* (Cambridge Texts in Applied Mathematics). Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9781139017329

6. Ozuğurlu, E. (2015). A note on the numerical approach for the reaction-diffusion problem to model the density of the tumor growth dynamics. *Computers and Mathematics with Applications*, 69(12), 1504–1517.

7. Xu, Y., Feng, J., Li, J., & Zhang, H. (2013). Stochastic bifurcation for a tumor–immune system with symmetric Lévy noise. *Physica A: Statistical Mechanics and its Applications*, 392(20), 4739–4748.

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

The initial-boundary value problem for the higher-order nonlinear Schrödinger equation on the half-line

Aykut Alkın
İYTE, Mathematics, İzmir, Turkey
aykutalkin@iyte.edu.tr

Abstract:
In this talk, we discuss the local well-posedness of the initial boundary value problem for the higher-order nonlinear Schrödinger equation (HNLS) on the half-line with a single boundary condition. The higher-order NLS, which arises in various physical contexts such as nonlinear optics and quantum mechanics, is considered within the framework of Sobolev spaces. We analyze the existence, uniqueness, and continuous dependence of solutions on initial data, focusing on the influence of the boundary condition in the half-line setting. The approach combines techniques from functional analysis, dispersive estimates, and the theory of nonlinear evolution equations. A key tool in our analysis is the application of Fokas' method, which provides a powerful framework for solving boundary value problems for integrable equations. We show how this method is adapted to the higher-order NLS, enabling a detailed understanding of the solution's behavior in the presence of the boundary condition.

Keywords: Fokas method, Strichartz estimates

References

1. Alkın, A., Özsarı, T., Mantzavinos, D. (2024). Local well-posedness of the higher-order nonlinear Schrödinger equation on the half-line: Single-boundary condition case. *Studies in Applied Mathematics*, *152*(1), 203-248. https://doi.org/10.1111/sapm.12642

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

DRBEM Solution of Singularly Perturbed Magnetohydrodynamic Duct Flow using Parallel Computing

Sinem Arslan Ölçer[1], **Münevver Tezer-Sezgin**[2]
[1]*Department of Mathematics, Middle East Technical University, Ankara, Turkey*
[2]*Department of Mathematics, Middle East Technical University, Ankara, Turkey*
arsinem@metu.edu.tr, munt@metu.edu.tr

Abstract:
This study focuses on the numerical solution of singularly perturbed magnetohydrodynamic (MHD) flow in a square duct for no-slip and insulted walls at high Hartmann numbers (Ha). The flow is steady, laminar, fully developed, and occurs in an incompressible, viscous, electrically conducting fluid, driven by a pressure gradient along a long pipe of square cross-section (duct). The governing equations of the MHD flow are of convection-diffusion type and are coupled through the velocity field $V(x, y)$ and the induced magnetic field $B(x, y)$. When a strong external magnetic field is applied horizontally, Hartmann number (Ha) increases significantly, enhancing the convection effects in the system. This leads to convection-dominated behavior in the coupled equations, with the diffusion terms becoming negligible. As a result, the system becomes a singularly perturbed problem characterized by thin boundary layers near the walls and it is very difficult to capture the flow behavior near the walls. To address this problem numerically, parallel computation of the Dual Reciprocity Boundary Element Method (DRBEM) is utilized in conjunction with a Shishkin mesh, which adapts the number of nodes taken on the boundary and Ha. The incorporation of parallel computing is essential in this framework, as it not only significantly reduces the computational time but also enables us to reach extremely large Hartmann numbers up to 1500. The numerical results demonstrate that the expected features of MHD duct flow emerge clearly and accurate solutions for both $V(x, y)$ and $B(x, y)$ can be obtained.

Keywords: MHD, Parallel computing, Singular perturbation, DRBEM, Shishkin mesh

References

1. U. Müller and L. Bühler (2001). *Magnetofluiddynamics in channels and containers*. Springer.
2. P. W. Partridge, C. A. Brebbia, *et al.*. *Dual reciprocity boundary element method*. Springer.
3. J. Miller, and E. O'riordan, and G. Shishkin (1996). *Fitted numerical methods for singular perturbation problems: error estimates in the maximum norm for linear problems in one and two dimensions*. Wiley Online Library.

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Optimizing Production and Recycling Decisions for Make-to-Stock Hybrid Manufacturing Systems Using Real-Time Information on Products in Use

Oktay Karabağ[1], Fikri Karaesmen[2], Barış Tan[3]

[1] *College of Engineering, İzmir University of Economics, Sakarya Caddesi No:156, Balçova, 35330, İzmir, Türkiye*

[2] *College of Engineering, Koç University, Rumeli Feneri Yolu, Sarıyer, 34450, İstanbul, Türkiye*

[3] *College of Engineering, Özyeğin University, Çekmeköy Campus Nişantepe Mahallesi, Orman Sokak, Çekmeköy, 34794, İstanbul, Türkiye*

oktay.karabag@ieu.edu.tr, fkaraesmen@ku.edu.tr, baris.tan@ozyegin.edu.tr

Abstract:
In this study, we consider a producer that manufactures a single product to stock using either virgin or returned materials to meet random demand. The manufacturer tracks the number of products in use via an information system and can fully observe the levels of returned and finished goods materials. After a random usage time, a fraction of the end-of-life products used by customers is returned to the producer while the remaining products are disposed of. The producer either accepts the returned products to be stored in the returned material inventory for recycling or scraps them upon their arrival. We model this system as a Markov Decision Process to determine an optimal control policy that specifies when to produce finished goods using either returned or virgin materials, and when to scrap or recycle end-of-life products, based on the number of products in use, as well as the levels of returned and finished goods materials. To obtain the control policies numerically, we also propose a linear programming formulation. We further develop a naive policy that ignores information on the number of products in use and relies only on two thresholds based on finished goods and returned materials inventory levels. Through a series of numerical experiments, we show that this naive policy provides a good approximation, with an average relative difference of approximately 3% from the optimal solutions, ranging from 0% to 69%. We also study the extent to which enforcing a minimum reliance on returned materials in production affects system performance measures.

Keyword: Circular Economy, Hybrid Manufacturing Systems, Linear Programming, Markov Decision Processes

References

1. Flapper, S. D. P., Gayon, J. P., & Vercraene, S. (2012). Control of a production–inventory system with returns under imperfect advance return information. European Journal of Operational Research, 218(2), 392-400.

2. Flapper, S. D., Gayon, J. P., & Lim, L. L. (2014). On the optimal control of manufacturing and remanufacturing activities with a single shared server. European Journal of Operational Research, 234(1), 86-98.

3. Karabağ, O., Karaesmen, F., & Tan, B. (2025). Purchasing and remanufacturing decisions with different quality returned material and finished goods. International Journal of Production Research, 1-18.

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Modified Vine Copula Classifiers With Application to Gene Expression Data

Tolga Yamut[1], **Burcu Hüdaverdi**[1]
[1]*Department of Statistics, Dokuz Eylül University, İzmir, Turkey*
yamut.tolga@ogr.deu.edu.tr, burcu.hudaverdi@deu.edu.tr

Abstract:
Statistical learning is a field focused on recognizing data patterns through inferential and predictive approaches. Within this domain, vine copulas offer a powerful and flexible framework for modeling complex dependencies (Bedford and Cooke 2002). As a class of multivariate density functions, vine copulas allow for fine-grained control over variable interactions, making them well-suited for high-dimensional pattern recognition tasks. In this study, the capabilities of vine classifiers are examined for supervised classification. Custom modifications are applied, and improvements are investigated. Bernstein copulas (Sancetta and Satchell 2004) are integrated into vine classifiers to obtain non-parametric and hybrid. For efficiency and to avoid overfitting truncated vine framework is also structured by validation set accuracy criteria (Brechman 2012) (Carrera, D. 2019). Simulation and real data studies classification applications are made. Benchmark gene expression data is used for the classification of various cancer type stages. The prominent genes of each cancer type are interpreted according to the Human Protein Atlas Portal. In general, one can conclude that high accuracy performance can be achieved without fully calibrating the vine structure. For the classification of gene data, there is a slight increase in performance when truncation is used. On the other hand, the hybrid vine does not exhibit a boosting effect and performs comparably to parametric models. Especially for the uterus gene data, the non-parametric truncated vine yields the most balanced and highest performance. In cross-validation, some truncations indicate an initial cut, which suggests that naive Bayes logic is effective in certain cases.

Keywords: Vine Bayes, Truncated Vine, Bernstein Copula, Statistical Learning

References

1. Bedford, T., and Cooke, R.M. (2002). Vines: A new graphical model for dependent random variables. *Annals of Statistics*, *30*(4), 1031-1068.

2. Brechmann, E. , Czado, C., and Aas, K. (2012). Truncated regular vines in high dimensions with application to financial data *Canadian Journal of Statistics*, *40*, 68-85.

3. Sancetta, A., and Satchell, S.(2004). The bernstein copula and its applications to modeling and approximations of multivariate distributions *Econometric theory*, *20*, 535-562.

4. Carrera, D., Bandeira, L., Santana, R., and Lozano, J. A. (2019). Detection of sand dunes on Mars using a regular vine-based classification approach *Knowledge-Based Systems*, *163*, 858-874.

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Classification of Returns in Crypto Market

Yusuf Can SEVİL[1]
[1]*Botrafy, Dubai, AE*
yusuf.sevil@botrafy.com

Abstract:
Botrafy is a versatile trading framework that performs historical data analysis for each market (Crypto, TR BIST, EU/US) and symbol, evaluates the data using statistical methods, and develops probability-based trading models through simulations. Despite operating across different markets such as cryptocurrencies and equities, it optimizes all processes through a unified codebase. By leveraging volatility-based dynamic parameters, it aims to minimize risks while maximizing profitability. Classifying financial returns is a challenging task due to their volatile and unpredictable behavior. In this study, we designed an end-to-end process covering all stages from the generation of synthetic data—created through simulations reflecting various market scenarios—to the implementation of machine learning workflows. Using the PyCaret library (Moez, 2020) in Python, we trained and evaluated multiple classification models. Based on a comprehensive comparison across various performance metrics—including Accuracy, AUC, Recall, Precision, F1-score, Kappa, and MCC—the Extra Trees Classifier consistently delivered the best results, demonstrating strong and reliable performance in return classification.

Keywords: Botrafy, Crypto Market, Classification, Machine Learning, Return

References

1. Moez, A. (2020). PyCaret: An open source, low-code machine learning library in Python (Version 1.0.0). Retrieved from https://www.pycaret.org

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Some Results on Linear Hilfer Fractional Difference Equations

Halis Can Koyuncuoğlu
Izmir Katip Celebi University, Department of Engineering Sciences, Izmir, Turkey
haliscan.koyuncuoglu@ikcu.edu.tr

Abstract:
In this talk, we focus on the Hilfer nabla fractional differences and exhibit their main characteristics. Then, we turn our attention to linear Hilfer nabla difference equations, and firstly, we study cobweb models involving Hilfer nabla fractional differences and obtain the convergence of their solutions. Subsequently, we investigate the sufficent conditions for the Hyers-Ulam stability of abstract linear Hilfer fractional difference equations. Since Hilfer nabla differences can be considered as a relaxation and generalization of fractional differences (Riemann-Liouville and Caputo fractional differences), our results improve and generalize the existing literature.

Keywords: Hilfer nabla difference, $\mathcal{N}$-transform, linear Hilfer fractional difference equation, cobweb model, Hyers-Ulam stability

References

1. Hilfer, R. (2000). *Applications of Fractional Calculus in Physics*. World Scientific.
2. Jonnalagadda J.M., & Gopal N.S. (2020). On Hilfer-type nabla fractional differences *Int. J. Differ. Equ.*, *15*(1), 91-107.
3. Koyuncuoğlu H.C., & Kaymak Ö.Ö., & Jonnalagadda J.M. (2025). Cobweb models with Hilfer fractional differences *Chelyabinsk Physical and Mathematical Journal*, to appear.
4. Koyuncuoğlu H.C., & Kostic M., & Jonnalagadda J.M. (2025). Hyers-Ulam stability for Hilfer nabla fractional difference equations, in preparation.
5. Gandolfo G. (1980). *Economic Dynamics: Methods and Models. Advanced Textbooks in Economics*. North-Holland Publishing.

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Sheffer Stroke Hilbert Algebras Stabilizing by Ideals

Tugce Katican[1], **Hashem Bordbar**[2]
[1]*Department of Mathematics, Izmir University of Economics, Izmir, Turkey*
[2]*Centre for Information Technologies and Applied Mathematics, University of Nova Gorica, Nova Gorica, Slovenia*
tugce.katican@ieu.edu.tr, hashem.bordbar@ung.si

Abstract:
The main goal of this study is two-fold: as the first target, a new characterization of Sheffer stroke Hilbert algebras is presented in light of the ideals. In this task, proper subsets of Sheffer stroke Hilbert algebras are introduced, and it is shown that the proposed subsets possess the relationship between lattice and set-theoretical operators. Secondly, we define stabilizers of Sheffer stroke Hilbert algebras for their nonempty subsets and underline their crucial properties. In the setup of the main results, we construct particular subsets of Sheffer stroke Hilbert algebras and we propose important properties of these subsets by investigating whether these sets are ideals or not. Furthermore, we investigate whether the introduced subsets of Sheffer stroke Hilbert algebras are minimal ideals. Afterwards, we define stabilizers in a Sheffer stroke Hilbert algebra and obtain their set theoretical properties. As an implementation of the theoretical findings, we present numerous examples, illustrative remarks and elaborative discussions.

Keywords: (Sheffer stroke) Hilbert algebra, Sheffer operation, ideal, stabilizer

References

1. Oner, T., Katican, T., & Borumand Saeid, A. (2021). Relation between Sheffer stroke and Hilbert algebras. *Categ. Gen. Algebr. Struct. Appl.*, *14*, 245-268. https://doi.org/10.29252/CGASA.14.1.245

2. Oner, T., Katican, T., & Borumand Saeid, A. (2021). Fuzzy filters of Sheffer stroke Hilbert algebras. *J. Intell. Fuzzy Syst.*, *40*, 759-772. https://doi.org/10.3233/JIFS-200760

3. Oner, T., Katican, T., & Borumand Saeid, A. (2021). Neutrosophic N-structures on Sheffer stroke Hilbert algebras. *Neutrosophic Sets Syst.*, *42*, 221-238. https://doi.org/10.5281/zenodo.4711530

4. Oner, T., Katican, T., & Borumand Saeid, A. (2023). Fuzzy ideals of Sheffer stroke Hilbert algebras. *Proc. Natl. Acad. Sci. India Sect. A Phys. Sci.*, *93*, 85-94. https://doi.org/10.1007/s40010-022-00794-9

5. Zhu, K., Wang, J., & Yang, Y. (2019). On two new classes of stabilizers in residuated lattices. *Soft Comput.*, *23*, 12209-12219. https://doi.org/10.1007/s00500-019-04204-y

6. Borumand Saeid, A., & Mohtashamnia, N. (2012). Stabilizer in residuated lattices. *Politehn. Univ. Buchar. Sci. Bull. Ser. A Appl. Math. Phys.*, *74*, 65-74.

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

On Regularity of the Discrete Hardy-Littlewood Maximal Operator

Hikmet Burak Özcan[1]
[1]*Department of Mathematics, Izmir Institute of Technology, Izmir, Turkey*
hikmetozcan@iyte.edu.tr

Abstract:
For a sequence of independent and identically distributed random vectors, we consider the conditional ordering concerning the magnitudes of some continuous function defined on the support set and satisfying certain regularity conditions. We also consider the Progressive Type-II right censoring for multivariate observations using conditional ordering. The need for the conditional ordering of random vectors exists for example, in reliability analysis when a system has n independent components each consisting of p arbitrarily dependent and parallel connected elements. I will present some results related to the theory of multivariate ordering, Progressively Type-II ordering, and multivariate records. The concept of multivariate records will be also discussed. Some examples of applications in economy and reliability analysis will be provided.

Keywords: Hardy-Littlewood maximal function, Discrete harmonic analysis, Regularity theory.

References

1. F. Temur, *The second derivative of the discrete Hardy-Littlewood maximal function*, $arXiv$: 2205.03953 [math.CA], 2022.

2. F.Temur, H. B. Özcan, *The higher regularity of the discrete Hardy-Littlewood maximal function*, $arXiv$: 2504.13019 [math.CA], 2025.

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Stability Analysis Of Nonlinear Time-Varying Systems In Cascade

Derya ÖZDEMİR[1]

[1] *Department of Mathematics, Izmir Institute of Technology, Izmir, Turkey*

deryacokgur@iyte.edu.tr

Abstract:

This work presents a stability analysis framework for nonlinear time-varying dynamical systems rearranging into a hierarchical structure. By decomposing the nonlinear large-scale system into interconnected subsystems, we use the hierarchical form to establish sufficient conditions for uniform asymptotic stability of overall system. A key focus is placed on the interconnection terms, which capture the dynamic influence between subsystems. We analyze how these interconnections affect the stability properties of the overall system and derive conditions under which their effect remains bounded and decaying over time. Our approach relies on the second method of Lyapunov adapted to the hierarchical form.

Keywords: Cascade systems, Stability analysis, Lyapunov method

References

1. Vidyasagar, M. (1980). Decomposition techniques for large-scale systems with nonadditive interactions: Stability and stabilizability. *IEEE transactions on automatic control*, *25*(4), 773-779.

2. H. K. Khalil, (2002). *Nonlinear Systems*. Prentice Hall, Upper Saddle River, 2002.

3. Zhou, B. (2017). Stability analysis of non-linear time-varying systems by Lyapunov functions with indefinite derivatives. *IET Control Theory and App.*, *11*(9), pp.1434-1442.

4. Şahan, G., & Özdemir, D. (2024). Uniform asymptotic and input to state stability by indefinite Lyapunov functions. *European Journal of Control*, *76*, 100945.

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

A Mass-Conservative Numerical Method For The Nonlinear Schrödinger Equation

Sıla Selenay Koç[1], **Ayhan Aydın**[2],
[1]*İzmir University of Economics, İzmir, Turkey*
[2]*Atılım University, Ankara, Turkey*
sila.selenay@ieu.edu.tr, ayhan.aydin@atilim.edu.tr

Abstract:
Numerous phenomena in mathematical physics, including water wave propagation, solid media behavior, and biomolecular dynamics, can be described using nonlinear partial differential equations. Single-wave propagation in an optical fiber is modeled by the nonlinear cubic Schrödinger (NLS) equation is modeled with

$$iU_t + \beta U_{xx} + k|U|^2 U = 0$$

where k is a constant, $U(x,t)$ is a complex valued function. Since the NLS equation is a nonlinear partial differential equation, its exact solution is not possible; however, periodic and solitary wave solutions are available under special conditions. Therefore, numerical solution is essential to understand the dynamics of the model. However, not every numerical method, such as the 4^{th} order explicit Runge-Kutta method, which is frequently used in the literature, gives reliable results. Inappropriate numerical discretizations can easily lead to "explosion" and create "numerical chaos". It is known that structure-preserving numerical methods give better and more reliable results than non-structure-preserving methods. In this study, we propose a new structure-preserving numerical scheme for the nonlinear Schrödinger (NLS) equation, based on the Crank–Nicolson method. The existence of the numerical solution is shown. The effectiveness of the method is supported by theoretical results.

Keywords: Finite Difference Schemes, Nonlinear Schrödinger Equation, Numerical Analysis

References

1. A. S. Davydov, *Solitons in Molecular Systems*, Reidel, Dordrecht, 1985.
2. J. M. Sanz-Serna, *Studies in Numerical Nonlinear Instability I. Why do Leapfrog Schemes Go Unstable* SIAM Journal on Scientific and Statistical Computing 6(4) 1985.
3. A. Aydın, B. Karasözen, *Symplectic and multisymplectic Lobatto methods for the "good" Boussinesq equation*, J. Math. Phys. 49, 083509 (2008).

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

A Numerical Approach for the HIV Infection Model Involving Latently Infected Cells

Demet Ersoy Özdek[1], **Sevin Gümgüm Turhan**[1]
[1]*Izmir University of Economics, Department of Mathematics, Izmir, Turkey*
demet.ersoy@ieu.edu.tr, sevin.gumgum@ieu.edu.tr

Abstract:
This study focuses on the mathematical model of Human Immunodeficiency Virus (HIV) infection. The HIV infection model describes the transition of the infection through the uninfected T cells (T), infected T cells (I) and free virus particles (V). In this study, the infected T cells are partitioned into two groups: Latently infected T cells (I*) and actively infected T cells (I). Latently infected cells refer to the infected cells that do not immediately become active, while actively infected cells can infect the healthy cells. Hence the model consists of four nonlinear differential equations. The literature of this system lacks the analytic solution. So, we use the Lucas wavelet method to solve the equations numerically and obtain their approximate solutions in terms of Lucas wavelets. Furthermore, we solve the model with different values of the parameters to investigate the effects of the problem parameters on the spread of HIV infection. The Lucas wavelet method is easy to implement, since linearization of the nonlinear terms and discretization of the time interval are not required. This provides a computational advantage for the method. In order to examine the efficiency, the obtained solutions are compared with the fourth order Runge Kutta method. The accuracy of the solutions is checked via residual error analysis, and the results are given in graphics.

Keywords: Hiv Infection Models, Latently Infected T Cells, Lucas Wavelets.

References

1. Thirumalai S, Seshadri R, Yüzbaşı Ş. On the solution of the human immunodeficiency virus (hiv) infection model using spectral collocation method, Int. J. Biomath. 2021; 14(2): 2050074. doi:10.1142/S1793524520500746.

2. Ghoreishi M, Ismail A, Alomari A. Application of the homotopy analysis method for solving a model for hiv infection of cd4(+) t-cells, Math. Comput. Model. 2011; 54: 3007-3015. doi:10.1016/j.mcm.2011.07.029

3. Beler A., Özaltun Şimşek G., Gümgüm S. Numerical Solutions of the HIV Infection Model of CD4(+) Cells by Laguerre Wavelets. Mathematics and Computers in Simulation 2023; 209: 205-219. doi: 10.1016/j.matcom.2023.02.016

4. Koshy T. Fibonacci and Lucas Numbers With Applications. Pure and Applied Mathematics, Wiley-Interscience, New York, 2001.

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Optimized team distribution in disaster situations using AHP and MILP methods

Ali Oğulyaymış[1] **, Yunus Emre Demirtaş**[1]
[1]*Department of Mathematics, Izmir University of Economics, Izmir, Türkiye*
ali.ogulyaymis@std.ieu.edu.tr, yunus.demirtas@std.ieu.edu.tr

Abstract:
In this study, our objective is to create different variants of optimization models for the planning of emergency response teams after an earthquake. In these models, our goal is to form optimized rescue teams that consider different scenarios that can occur during an intervention in an earthquake in Izmir. During the assignment of teams, variables such as the damage distribution and the level of damage in the districts affected by the earthquake were determined as optimization objectives. There are two different optimization methods. One of them is the Analytical Hierarchy Process (AHP) and the Mixed Integer Linear Programming (MILP) method. Relative risk values are given for all districts. These risk values are calculated according to the maximum-minimum normalization technique, where they vary between 1 and 10, and a classification is performed accordingly.

Keywords: Optimization, MILP, AHP, Disaster, Earthquake

References

1. INSARAG(2020).Volume II,Manual B-Operations.
https://insarag.org/methodology/insarag-guidelines/

2. Akdas, E.& Eren, T. (2023). Establishment of Search and Rescue Teams in Disaster and Emergency Management *Journal of Disaster and Risk*, *6*(3),
https://dergipark.org.tr/tr/pub/afet/issue/80195/1267389

3. Vaidya, O.S.& Kumar, S. (2006). Analytic hierarchy process: An overview of applications. *European Journal of Operational Research 169*1, (pp. 1-29).
https://doi.org/10.1016/j.ejor.2004.04.028

4. Wolsey, L.A. (1998). Integer Programming.
https://onlinelibrary.wiley.com/doi/book/10.1002/9781119606475

Advisor: Prof. Dr. Gözde Yazgı TÜTÜNCÜ

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

A New CURE-Based Fuzzy Classification

Alican Akca[1]
[1]*Department of Mathematics, Izmir University of Economics, Izmir, Türkiye*
alican.akca@std.ieu.edu.tr

Abstract:
Traditional clustering algorithms often face challenges with datasets containing non-spherical clusters or varying densities. CURE (Clustering Using Representatives) addresses this by using multiple, shrunk representative points per cluster, effectively capturing complex shapes and mitigating outlier effects. However, data points often exhibit ambiguity, belonging partially to multiple groups. Fuzzy logic further enhances CURE by allowing data points to belong to multiple clusters to varying degrees, using trapezoidal and triangular membership functions. This provides a more accurate way to represent points, especially those that lie between clusters. This study proposes a semi-supervised learning (classification with clustering) approach, called CURE-based fuzzy classification. This classification framework integrates CURE with fuzzy classification. CURE is used to identify class/cluster representatives, from which trapezoidal and triangular fuzzy membership functions are derived for each feature and class. Then classification is performed by assigning test samples to the class with the highest membership function, using a mean logarithmic aggregation strategy. We evaluated the approach on three benchmark datasets: Iris, Wisconsin Breast Cancer (Diagnostic), and Seeds. The proposed method achieved high accuracy on Iris (96.7%) and Breast Cancer (97.4%), with corresponding weighted F1 scores of 0.924 and 0.963. On the Seeds dataset, accuracy was 81.0% with per-class F1 scores of 0.81, 0.84, and 0.78. These results suggest that the integration of CURE and fuzzy logic is a promising approach for addressing classification challenges characterized by complex data patterns and uncertainty.

Keywords: CURE, Fuzzy classification, Semi-supervised learning, Membership functions, Clustering

References

1. R. A. Fisher. The use of multiple measurements in taxonomic problems. *Annals of Eugenics*, 7(2):179–188, 1936.

2. M. Charytanowicz, J. Niewczas, P. Kulczycki, P. A. Kowalski, S. Łukasik, and S. Ź ak. A Complete Set of Image Analysis Basic Methods for Wheat Grain Classification. In L. Rutkowski, R. Tadeusiewicz, L. A. Zadeh, and J. M. Zurada, editors, *Artificial Intelligence and Soft Computing*, volume 6113 of *Lecture Notes in Computer Science*, pages 183–192. Springer Berlin Heidelberg, 2010.

3. Sudipto Guha, Rajeev Rastogi, and Kyuseok Shim. CURE: An efficient clustering algorithm for large databases. *ACM SIGMOD Record*, 27(2):73–84, June 1998.

4. Anil K. Jain, M. Narasimha Murty, and Patrick J. Flynn. Data clustering: a review. *ACM Computing Surveys (CSUR)*, 31(3):264–323, 1999.

Advisor: Asst. Prof. Dr. Necla KOCHAN

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Hospital Bed Capacity Optimization Project For Departments with MILP and LP

Arda Erçakır[1]
[1]*Department of Mathematics, Izmir University of Economics, Izmir, Türkiye*
ercaKirarda02@gmail.com

Abstract:
Hospitals frequently face structural issues in managing bed capacities due to imbalanced allocations between departments. In many cases, existing resources are not planned in a way that reflects department-specific patient load or treatment requirements, which leads to decreased quality of care and reduced resource efficiency. In this study, we developed an optimization model aimed at improving the allocation of beds across hospital departments to enhance operational efficiency and care quality. In our project, we employed Linear Programming (LP) to proportionally allocate beds based on departmental demand and Mixed Integer Linear Programming (MILP) to model numerical constraints and binary decision variables such as resource transfers or the strategic opening/closing of units. Our model and methodological approach are based on several academic sources: the study by Kim and Oh (2021) guided the definition of the objective function and system constraints; the work of Sitepu et al. (2020) informed the modeling of realistic capacity limitations under the MILP framework; and the publication by Larsson and Fredriksson (2019) supported the integration of strategic planning parameters and binary decision logic into the model.This project proposes a flexible and literature-informed optimization model that responds to the growing need for data-driven hospital capacity planning, with the broader aim of supporting a more efficient and equitable delivery of healthcare services.

Keywords: Optimization, MILP, LP, Hospital Bed Capacity, Efficiency

References

1. Kim, J.-N., & Oh, I.-H. (2021). Mathematical modeling for hospital operations during COVID-19. *PubMed*.

2. Sitepu, S., Mawengkang, H., & Husein, I. (2020). Optimization model for hospital ward planning. *IOP Publishing Ltd Journal of Disaster and Risk*, *6*(3),

3. Larsson, A., & Fredriksson, A. (2019). Tactical Capacity Planning in Hospital Departments.

Advisor: Prof. Dr. Gözde Yazgı TÜTÜNCÜ

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Modeling Smoking Dynamics with Gegenbauer Polynomial Methods

Atahan Taşkın[1]
[1]*İzmir University of Economics, Department of Mathematics, Izmir, Turkey*
atahan.taskin@std.ieu.edu.tr,

Abstract:

This study presents an approach using Gegenbauer polynomials as the primary basis to model the dynamics of smoking behavior. The model describes transitions among four groups: potential smokers, light smokers, regular smokers, and quitters. While traditional numerical methods such as Euler provide basic approximations, this study explores an alternative approach based on polynomial functions to achieve better accuracy and more effective global approximation. By employing Gegenbauer polynomials, the model aims to reduce oscillations and improve approximation quality in higher-degree cases. For comparison, Chebyshev polynomials and the 4th-order Runge-Kutta method are also implemented to evaluate the performance difference in terms of convergence and solution behavior. Numerical experiments are conducted to compare the results of the Gegenbauer-based approach with classical numerical methods and the Chebyshev-based formulation. These comparisons aim to explore the potential of Gegenbauer polynomials as a suitable basis for solving complex time-dependent models, particularly in behavioral and epidemiological dynamics.

Keywords: Smoking Dynamics, Chebyshev Polynomials, Gegenbauer Polynomials,Spectral Methods, Polynomial Methods.

References

1. Huo H-F, Zhu C-C. Influence of relapse in a giving up smoking model. *AbstrAppl Anal* 2013:525461, 12 pages.

2. Qesmi R, Wu J, Wu JH, Heffernan JM. Influence of backward bifurcation in a model of hepatitis B and C viruses. *Math Biosci* 2010;224(2):118–25.

3. Rahman GU, Agarwal RP, Din Q. Mathematical analysis of giving up smoking model via harmonic mean type incidence rate. *Appl Math Comput* 2019;354:128–48.

Advisor: Assoc. Prof. Dr. Sevin GÜMGÜM

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

A Numerical Investigation of the Alcohol Consumption Model and Its Effects on Treatment Dynamics

Can Ege Türe[1]
[1]*Department of Mathematics, Izmir University of Economics, Izmir, Turkey*
can.ture@std.izmirekonomi.edu.tr

Abstract:
The aim of this study is to model and analyze the alcohol consumption behavior across six populations: potential drinkers, moderate drinkers, heavy drinkers, individuals undergoing private treatment, individuals undergoing public treatment, and individuals who have recovered and quit drinking. The model is solved by using two numerical approaches. We use the Laguerre polynomials to obtain the numerical solutions. Since the analytical solution of the model does not exist, we compare the numerical results with the results of the fourth-order Runge-Kutta method. We compare the results of both methods to show the accuracy of the current method and observe that they agree very well. It is expected that the Laguerre approximation provides a structured solution, although some discrepancies may appear, especially in smaller compartments. Following the numerical solution phase, a comprehensive parameter analysis is being conducted to evaluate the influence of transition and recovery rates on alcohol consumption dynamics. This ongoing study aims to enhance the understanding of system behavior and to assess the stability of the modeling approaches.

Keywords: Alcohol consumption model, Laguerre polynomials, Runge-Kutta method, Parameter analysis, Numerical modeling

References

1. Khajji, B., Labzai, A., Balatif, O., & Rachik, M. (2020). Mathematical modeling and analysis of an alcohol drinking model with the influence of alcohol treatment centers. *International Journal of Mathematics and Mathematical Sciences*, *2020*, 1–16.https://doi.org/10.1155/2020/5489206

2. Adu, I., Osman, M., & Yang, C. (2017). Mathematical model of drinking epidemic. *British Journal of Mathematics & Computer Science*, *22*(4), 1–10. https://doi.org/10.9734/BJMCS/2017/34603

3. Agrawal, A., Tenguria, A., & Modi, G. (2018). Role of epidemic model to control drinking problem. *International Journal of Scientific Research in Mathematical and Statistical Sciences*, *5*(6), 324–337.

Advisor: Assoc. Prof. Dr. Sevin GÜMGÜM

Acknowledgements: This study was supported by TUBITAK 2209-A University Students Research Projects Support Program (Project No: 1919B012464459). We would like to thank TUBITAK for the support.

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

A New Model for Birth and Death Processes in Stochastic Processes

Ceren Gibyeli[1]
[1]*Department of Mathematics, İzmir University of Economics, İzmir, Turkiye*
ceren.gibyeli@std.izmirekonomi.edu.tr

Abstract:
This study analyses the birth-death process, which is stochastic process, with a new model that includes interstates. In this new model, two different interstates were identified that can occur during the transition of the system to the next state. The transition to the next state, E_k is calculated as the probability of passing through two different interstates, E'_k and E''_k. In general, the transition to the next state involves two different interstates, while the transition to the previous state does not involve these interstates. The aim here is to show how these interstates differ from the classical birth and death processes. For this purpose, the conditional transition probabilities of the system between states and interstates and their parametric representations are determined in the specified time interval $[t, t + h]$. This time interval also includes the time interval of transition to two different interstates, the time interval of transition from the forward motion state to the next interstate is determined as $[t, t + h_1]$. The sum of the probabilities of the system from the specified state to the next state, to the previous state and to the current state was calculated using the total probability formula. The differential equation of this parametric representation is constructed and a system of equations is also constructed using the specified initial points. As a result, interstates are added to the classical processes of birth and death and a theoretical reconstruction is made with these interstates.

Keywords: Birth and Death Process, Conditional Transition Probability, Total Probability Formula, Interstates

References

1. Feller, W. (1968). *An Introduction to Probability Theory and Its Applications*. Wiley.
2. Taylor, M., Karlin, S. (1998). *An Introduction to Stochastic Modelling*. American Press.
3. Ross, S. (1996). *Stochastic Process*. Wiley.
4. Karlin, S., McGregor, J. L. (1957). The Differential Equations of Birth-and-Death Processes, and the Stieltjes Moment Problem. *Transactions of the American Mathematical Society*, *85*(2), 489-546.

Advisor: Prof. Dr. İsmihan BAYRAMOGLU

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Modeling Online Game Addiction Dynamics via Nonlinear SIPQ Equations

Elif İlkin Ersoy[1]
[1] *Department of Mathematics, Izmir University of Economics, Izmir, Türkiye*
elif.ilkin@std.izmirekonomi.edu.tr

Abstract:

This research focus on SIPQ model for online game addiction. The spread and evolution of online game addiction within a population is described as an epidemic model that divides the population into four compartments: Susceptible (S), Infective (I), Professional (P), Quitting (Q) individuals. The model is given as a nonlinear system of ordinary differential equations with no explicit analytical solution. To address this, a collocation method based on Lucas polynomials is applied. The approximate solution is expressed as a truncated series of Lucas polynomials. These polynomials are chosen for their operational simplicity and their ability to enhance the accuracy of series-based approximation methods. Due to their orthogonal properties, Lucas polynomials offer both high accuracy and rapid convergence in the numerical solution of differential equations. In order to check the efficiency, the results are compared with the standard fourth-order Runge-Kutta (RK4) method. Residual error analysis is used to confirm the accuracy of the approximate solution. The results are presented in graphics and in tables.

Keywords:, Online Game Addiction,Numerical Solution, Lucas Polynomial, Collocation Method, Runge-Kutta Method, Residual Error

References

1. Kuss, D. J., & Griffiths, M. D. (2012). Online gaming addiction: A review of the literature. *International Journal of Mental Health and Addiction*

2. Young, K. S. (2009). *Internet addiction: A Handbook and Guide to Evaluation and Treatment*. John Wiley & Sons.

3. Li, T., & Guo, Y. (2019). Stability and Optimal Control in a Mathematical Model of Online Game Addiction.

4. Iserles, A. (2009). *A First Course in the Numerical Analysis of Differential Equations*. Cambridge University Press.

Advisor: Asst. Prof. Dr. Demet ERSOY ÖZDEK

Acknowledgements: This study was supported by TUBITAK 2209-A University Students Research Projects Support Program (Project No: 1919B012470946). We would like to thank TUBITAK for the support.

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Comparative Clustering Analysis of the Human Development Index Using K-Means with Various Distance Metrics

Fatma Ebru Zozuk[1]
[1]Department of Mathematics, Izmir University of Economics, Izmir, Turkey
fatma.zozuk@std.ieu.edu.tr

Abstract:
This study investigates the impact of different distance metrics on the performance of k-means clustering, a widely used technique in data analysis. The k-means algorithm partitions data points into clusters based on their proximity to cluster centers. The choice of distance metric can significantly affect clustering outcomes. In this research, seven common distance metrics—Euclidean, Manhattan, Chebyshev, Canberra, Cosine, Mahalanobis, and Minkowski—are evaluated to assess their influence on cluster formation and data point assignment. The results offer insights into how selecting an appropriate distance metric can enhance the effectiveness of k-means clustering on the HDI dataset.

Keywords: Human development, HDI, K-means, Distance metrics

References

1. A. Singh, A. Yadav, and A. Rana, *K-Means with Three Different Distance Metrics*, International Journal of Computer Applications, vol. 67, no. 10, 2013.

2. S. A. Afghani and W. Y. M. Putra, *Clustering with Euclidean Distance, Manhattan - Distance, Mahalanobis - Euclidean Distance, and Chebyshev Distance with Their Accuracy*, Indonesian Journal of Statistics and Its Applications, vol. 5, no. 2, pp. 369–376, 2021.

3. Z. Shapcott, *An Investigation into Distance Measures in Cluster Analysis*, arXiv preprint arXiv:2404.13664, 2024.

4. GeeksforGeeks. (n.d.). *Cosine Similarity - Understanding the math and how it works*. Retrieved April 26, 2025, from https://www.geeksforgeeks.org/cosine-similarity/

5. T. M. Ghazal et al., *Performances of K-Means Clustering Algorithm with Different Distance Metrics*, Intelligent Automation and Soft Computing, vol. 30, no. 2, pp. 735-742, 2021.

6. S. Lloyd, *Least squares quantization in PCM*, IEEE Transactions on Information Theory, vol. 28, no. 2, pp. 129–137, 1982.

7. M. R. Berthold and F. Höppner, *On Clustering Time Series Using Euclidean Distance and Pearson Correlation*, arXiv preprint arXiv:1601.02213, 2016.

8. L. K. Armah and I. Melnykov, *K-Means Clustering With Incomplete Data with the Use of Mahalanobis Distances*, arXiv preprint arXiv:2411.00870, 2024.

9. E. Schubert, A. Lang, and G. Feher, *Accelerating Spherical k-Means*, arXiv preprint arXiv:2107.04074, 2021.

Advisor: Asst. Prof. Necla KOÇHAN

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

A Data Based Statistical Reliability Evaluation

Gülceren IŞIK[1]
[1]*Department of Mathematics, Izmir University of Economics, Izmir, Turkey*
gulceren.isik@std.izmirekonomi.edu.tr

Abstract:
Accurate reliability analysis of machines in manufacturing systems is essential for ensuring production continuity and minimizing maintenance costs. This study focuses on evaluating the time-based performance of machines using failure data modeled with three different probability distributions, and on developing data-driven decision support strategies. Descriptive statistical analyses were initially conducted for each dataset, followed by the identification of appropriate probability distributions. Parameters for these distributions were estimated, and model fits were assessed using metrics such as log-likelihood and Akaike Information Criterion (AIC). Based on the selected models, mean residual life (MRL) values were calculated, and graphical analyses of reliability functions—such as cumulative failure probability, reliability, and hazard rate—were performed. In the final stage, a basic cost analysis was carried out for single-component systems using the reliability parameters. This analysis allows the timing of failures and the remaining life of the system to be considered to determine appropriate intervals for maintenance or replacement, in order to support effective decision making. Overall, the study demonstrates the practical value of statistical reliability methods in industrial environments and underlines the importance of selecting appropriate distribution models for failure data to enhance the implementation of reliability-based analytics in manufacturing systems.

Keywords: Reliability Analysis, Mean Residual Lifetime, Availability, Data Analysis, Statistical Methods, Cost

References

1. Lisnianski, A. & Levitin, G. (2003). *Multi-state system reliability: assessment, optimization, applications*. World Scientific Publishing Company, Singapore.

2. Iscioglu, F. (2017). Dynamic performance evaluation of multi-state systems under non-homogeneous continuous time Markov-process degradation using life-times in terms of order statistics. *Proc IMechE Part O: Journal of Risk and Reliability*, *231*, 255–264.

3. Ahmad, R. & Kamaruddin, S. (2012). An overview of time-based and condition-based maintenance in industrial application. *Computers & Industrial Engineering*, *63*, 135–149.

4. Guess, F. & Proschan, F. (1988). Mean Residual Life: Theory and Applications. *Handbook of Statistics*, *7*, 215–224.

5. Eryilmaz, S. (2010). Mean residual and mean past lifetime of multi-states systems. *IEEE Transactions on Reliability*, *59*, 644–649. https://doi.org/10.1109/TR.2010.2054173

6. Devrim, Y. & Eryilmaz, S. (2020). Reliability-based evaluation of hybrid wind-solar energy system. *Proc IMechE Part O: Journal of Risk and Reliability*, *235*, 136–143.

Advisor: Assoc. Prof. Dr. Cemal Murat ÖZKUT

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Reliability of Complex Systems Consisting of Two Types of Mixed Components

Hümay Zehra Özer[1]
[1]*Department of Mathematics, Izmir University of Economics, İzmir, Turkiye*
humay.ozer@std.izmirekonomi.edu.tr

Abstract:
We consider a coherent system consisting of two types of randomly selected components. The first type of components have lifetimes $X_1, X_2, \ldots, X_{n_1}$ with joint distribution function $F(x_1, x_2, \ldots, x_{n_1})$, and the second type of components have lifetimes $Y_1, Y_2, \ldots, Y_{n_2}$ with joint distribution function $G(y_1, y_2, \ldots, y_{n_2})$. The components' lifetimes of this system are $W_1, W_2, \ldots, W_n$, where $n = n_1 + n_2$ and W_i is either X_k, $k \in \{1, 2, \ldots, n_1\}$ or Y_j, $j \in \{1, 2, \ldots, n_2\}$. The reliability of the system is studied for particular multivariate distributions under the condition of exchangeability of random variables $X_1, X_2, \ldots, X_{n_1}$ and $Y_1, Y_2, \ldots, Y_{n_2}$. Some numerical calculations are provided in tables, and some illustrative graphs are provided.

Keywords: Exchangeable Random Variables, Coherent Systems Reliability

References

1. H.A. David, H.N. Nagaraja, *Order Statistics*, 3rd ed., Wiley, New York, 2003.
2. M. Asadi, I. Bairamov, A note on the mean residual life function of parallel systems, *Communications in Statistics — Theory and Methods*, vol. 34, pp. 1–12, 2005.
3. M. Asadi, I. Bairamov, On the mean residual life function of the k-out-of-n systems at system level, *IEEE Transactions on Reliability*, vol. 55, pp. 314–318, 2006.
4. M. Asadi, S. Goliforushani, On the mean residual life function of coherent systems, *IEEE Transactions on Reliability*, vol. 57, no. 4, pp. 574–580, 2008.
5. S. Gurler, I. Bairamov, Parallel and k-out-of-n:G systems with nonidentical components and their mean residual life functions, *Applied Mathematical Modelling*, vol. 33, no. 2, pp. 1116–1125, 2009.
6. Bairamov, I. and Parsi, S. (2011) Order statistics from mixed exchangeable random variables. *Journal of Computational and Applied Mathematics*, Volume 35, Issue 16, 4629-4638.
7. I. Bayramoglu (Bairamov), S. Eryılmaz, Order statistics of dependent sequences consisting of two different sets of exchangeable variables, *Journal of Computational and Applied Mathematics*, vol. 286, pp. 1–6, 2015.

Advisor: Prof. Dr. İsmihan BAYRAMOGLU

Acknowledgements: This study was supported by TUBITAK 2209-A University Students Research Projects Support Program (Project No: 1919B012408472). We would like to thank TUBITAK for the support.

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

City-Level Forecasting and Optimization of Irrigation Water Allocation Across Türkiye for 2025 Using Machine Learning and Linear Programming

Hümay Zehra Özer[1]
[1]*Department of Mathematics, Izmir University of Economics, İzmir, Turkiye*
humay.ozer@std.izmirekonomi.edu.tr

Abstract:

This study proposes a hybrid decision-support model that combines machine learning (ML) forecasting with linear programming (LP) to optimize irrigation water allocation at the city level in Türkiye for the year 2025. The LP model aims to maximize total irrigated agricultural area $\sum X_i$, subject to constraints: water availability ($W_i \leq \text{ReservoirFillRatio}_i \cdot C_i + \text{Precipitation}_i \cdot A_i$), irrigation demand ($W_i = X_i \cdot S_i$), land availability ($X_i \leq \text{AvailableLand}_i$), and non-negativity ($X_i, W_i \geq 0$), where W_i is allocated water, X_i is irrigated area, C_i is reservoir capacity, A_i is rain-fed area, and S_i is water required per hectare. Supervised ML models generate realistic input values: Random Forest Regressor helps capture nonlinear patterns in tabular data, while Long Short-Term Memory (LSTM) networks model temporal trends in climate variables. These models forecast key 2025 indicators such as precipitation, reservoir levels, and agricultural land, using historical data from the Turkish State Meteorological Service and the Turkish Statistical Institute. The predicted values are integrated into the LP model to produce city-specific irrigation plans. Results highlight the most water-efficient cities with the highest irrigation potential, evaluated via the X_i/W_i efficiency ratio. This approach enhances traditional optimization by incorporating data-driven environmental forecasting, offering a scalable and adaptive solution for sustainable agricultural water management under increasing climatic and resource pressures.

References

1. Turkish State Meteorological Service (MGM). *City-Based Rainfall Statistics*. Available at: `https://www.mgm.gov.tr`
2. Turkish Statistical Institute (TÜİK). *Agricultural Area and Reservoir Data*. Available at: `https://www.tuik.gov.tr`
3. F. Imron and Murtiningrum. (2021). *Optimization of irrigation water allocation using linear programming: A case study on Belitang irrigation system*. IOP Conf. Ser.: Earth Environ. Sci., 653, 012023.
4. R. A. Mahajan, et al. (2025). *Optimizing Irrigation Scheduling through Artificial Intelligence Techniques*. Int. Water & Irrigation, 44(1), 308–312.

Advisor: Prof. Dr. Gözde Yazgı TÜTÜNCÜ

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

A Numerical Investigation of the Alcohol Consumption Model and Its Effect on the Liver

Hüseyin Münir Pişkin[1]
[1]*Department of Mathematics, İzmir University of Economics, İzmir, Turkey*
munir.piskin@std.izmirekonomi.edu.tr

Abstract:
The aim of this study is to analyse the alcohol consumption behaviour of different population groups and the associated liver complications. The model consists of five compartments: potential drinkers, moderate drinkers, heavy drinkers, heavy drinkers with liver complications, and individuals who have recovered and quit drinking. This framework captures both the dynamics of alcohol use and the progression to liver-related health issues. The system is numerically solved using Bessel polynomials, and simulations are conducted to evaluate the method's effectiveness. Results show that this approach is easy to implement, computationally efficient for short-term analysis, and capable of producing accurate approximations. To verify its performance, the numerical results are compared with those obtained using the fourth-order Runge-Kutta method.

Keywords: Bessel Polynomials, Alcohol Model, Disease Modelling, Approximate Solutions

References

1. Bouchaib Khajji, Abdelfatah Kouidere, Omar Balatif, Mostafa Rachik. (2020). *Mathematical Modeling, Analysis and Optimal Control of an Alcohol Drinking Model with Liver Complication.* Commun. Math. Biol. Neurosci., 2020:32. https://doi.org/10.28919/cmbn/4553

2. Khajji, B., Labzai, A., Balatif, O., & Rachik, M. (2020). *Mathematical modeling and analysis of an alcohol drinking model with the influence of alcohol treatment centers.* International Journal of Mathematics and Mathematical Sciences, 2020, 1–16. https://doi.org/10.1155/2020/5489206

3. Agrawal, A., Tenguria, A., & Modi, G. (2018). *Role of epidemic model to control drinking problem.* International Journal of Scientific Research in Mathematical and Statistical Sciences, 5(6), 324–337.

Advisor: Assoc. Prof. Dr. Sevin GÜMGÜM

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Identification of Energy Suitability Areas with CSP Approach in Izmir

Merve Sevim Özkan[1]
[1]*Department of Mathematics, Izmir University of Economics, Izmir, Türkiye*
merve.ozkan@std.izmirekonomi.edu.tr

Abstract:
This study develops a site selection model to identify suitable sites for solar and wind power plants in Izmir province. Only real energy data such as solar radiation and wind speed are used in the model, while spatial factors such as land use, protected areas and distance to power transmission lines are defined as constraints. Since this multi-criteria problem cannot be solved directly by analytical methods, it is addressed with the Constraint Satisfaction Problem (CSP) approach. Geographic Information Systems (GIS) technologies were utilized in the implementation of the model and spatial data layers and raster analysis were used. The CSP model identifies suitable areas with a screening logic by performing suitability analysis according to certain threshold values. As a result, both the energy production potential and the level of constraint compliance of the identified potential areas were analyzed. This study contributes to simple but effective decision support approaches in renewable energy planning by demonstrating that effective site selection can be made even with limited data usage.

Keywords: CSP Model,Renewable Energy , Optimization

References

1. Gómez Sánchez, M., Masip Macia, Y., Fernández Gil, A., Castro, C., Nuñez González, S. M., & Pedrera Yanes, J. (2021). A mathematical model for the optimization of renewable energy systems. *Mathematics*, *9*(1), 39.

2. Demir, A., & Yılmaz, A. (2021). GIS-based site selection approach for wind and solar energy systems: A case study from western Turkey. *Renewable and Sustainable Energy Reviews*, *138*, 110593.

3. Tuğrul, B., & Aydın, N. Y. (2022). An integrated GIS-based ANP analysis for selecting solar farm installation locations: Case study in Cumra Region, Turkey. *Environment, Development and Sustainability*, *24*(12), 13738–13759.

4. Türkoğlu, M., & Karakaya, E. (2023). A GIS-based multi-criteria decision-making approach (GIS-MCDM) for determination of the most appropriate site selection of onshore wind farm in Adana, Turkey. *Renewable Energy*, *201*, 1002–1015.

5. Karakaya, E., & Güngör, A. (2021). Optimal site selection for solar photovoltaic (PV) power plants using GIS and AHP: A case study of Malatya Province, Turkey. *Sustainable Energy Technologies and Assessments*, *45*, 101184.

6. Dağdelen, T., & Doygun, H. (2022). GIS-based determination of suitable areas with multi-criteria approach for solar power plants and assessment of land decisions: The case study of İzmir. *Land Use Policy*, *115*, 106041.

Advisor: Prof. Dr. Gözde Yazgı TÜTÜNCÜ

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Legendre Polynomial Solution for Online Media Addictian and Depresssion Model

Merve Sevim Özkan[1]
[1]*Department of Mathematics, Izmir University of Economics, Izmir, Türkiye*
merve.ozkan@std.izmirekonomi.edu.tr

Abstract:
This study focuses on the SEIDRQ mathematical model describing online media addiction and depression. In the model, a compartmentalized structure based on the epidemiological SEIDRQ framework is studied to express possible transitions between psychological states. This model is solved by collocation method based on Legendre polynomials to obtain approximate solutions. Legendre polynomials are preferred because of their orthogonal properties which provide high accuracy in a bounded interval. Since there is no analytical solution of the model in the literature, the effectiveness of the method is checked by comparing the approximate solutions obtained with the results obtained by the Fourth-Order Runge-Kutta (RK4) method. These solutions are expressed as discrete series. In addition, residual functions are analyzed to assess the accuracy of solutions. The accuracy of the solutions is examined through residual analysis. By approximate solutions, this study contributes to the literature of the model.

Keywords: Legendre Polynomial, Residual Error, Collocation Method

References

1. Alemneh, H. T., & Alemu, N. Y. (2021). Mathematical modeling with optimal control analysis of social media addiction. *Infectious Disease Modelling*, *6*, 405–419. https://doi.org/10.1016/j.idm.2021.01.011

2. Ali, A. S., Javeed, S., Faiz, Z., & Baleanu, D. (2024). Mathematical modelling, analysis and numerical simulation of social media addiction and depression. *PLoS ONE*, *19*(3), e0293807. https://doi.org/10.1371/journal.pone.0293807

3. Maayaha, B., & Arqub, A. (2023). Hilbert approximate solutions and fractional geometric behaviors of a dynamical fractional model of social media addiction affirmed by the fractional Caputo differential operator. *Chaos, Solitons & Fractals: X*, *10*, 100092. https://doi.org/10.1016/j.csfx.2023.100092

4. Maria, A., Elinora, B., Leonardus, O., & Fried, B. (2023). Mathematical Modelling and Simulation of Social Media Addiction TikTok Using SEI1I2R Type Model. *Jurnal Diferensial*, *5*(1), 43–55. https://doi.org/10.35508/jd.v5i1.10401

5. Rashid, S., Ashraf, R., & Bonyah, E. (2022). Nonlinear dynamics of the media addiction model using the fractal fractional derivative technique. *Complexity*, *2022*, 2140649. https://doi.org/10.1155/2022/2140649

Advisor: Asst. Prof. Demet ERSOY ÖZDEK

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Time Management Optimization for University Students Using Nonlinear Programming

Mine Cansın Günay[1]
[1]*Department of Mathematics, Izmır University of Economics,Izmir, Turkiye*
cansin.gunay@std.izmirekonomi.edu.tr

Abstract:
This study aims to help university students balance their academic and social lives through a nonlinear optimization model. The model provides valuable insights for developing strategies that improve both academic performance and social well-being. Time management plays a key role in enabling students to manage their academic responsibilities along with their social lives, contributing significantly to both success and overall quality of life. The project explores the relationship between social balance and academic achievement by highlighting the benefits of effective time allocation. To achieve this, a nonlinear programming (NLP) model was developed to optimize students' daily time allocation across three key activities: sleep, study, and social interaction. The model uses real data collected from university students that includes variables such as age, gender, academic major, class level, GPA, and daily routines. Its goal is to maximize academic performance while minimizing the negative effects of insufficient sleep and limited social engagement. The findings reveal that optimal time management strategies vary across student profiles. Furthermore, the personalized recommendations generated by the model show strong potential to improve both academic outcomes and social impacts.

Keywords: time management, nonlinear,students, academic performance

References

1. Britton, B. K., & Tesser, A. (1991). Effects of time-management practices on college grades. *Journal of Educational Psychology*, *83*(3), 405–410.

2. Altın, M., & Öztürk, G. (2020). Üniversite öğrencilerinde zaman yönetiminin akademik başarıya etkisi. *Eğitim ve Bilim Dergisi*, *45*(202), 100–115.

3. Klassen, R. M. (2002). A question of calibration: A review of the self-efficacy beliefs of students with learning disabilities. *Learning Disability Quarterly*, *25*(2), 88–102.

Advisor: Prof. Dr. Gözde Yazgı TÜTÜNCÜ

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Reliability Analysis in Max-Min Models Using Order Statistics for Exponential and Weibull Distributions

Mine Cansın Günay[1],
[1] *Department of Mathematics , Izmir University of Economics, Izmir, Turkiye*
cansin.gunay@std.izmirekonomi.edu.tr

Abstract:
This paper examines the role of reliability analysis as a fundamental tool for assessing the performance, lifetime and structural integrity of systems in many fields ranging from engineering to finance, risk management to actuarial sciences. Reliability analysis makes important contributions to both the design and maintenance phases of complex systems, providing critical outputs such as predicting the probability of failure, analyzing time to failure, and assessing the expected uptime of components. These assessments enable the development of more robust systems, reducing system downtime, optimizing performance and lowering long-term costs. In this context, the Weibull and exponential distributions are the two main probability distributions frequently used in reliability modeling. Thanks to its flexible shape and scale parameters, the Weibull distribution can successfully model different failure behaviors such as early failures, random failures and wear-induced failures. This flexibility enables failure modeling of systems. On the other hand, the exponential distribution is widely used in modeling systems with time-invariant failure rates due to its constant failure rate assumption and memorylessness property. The paper proposes a holistic reliability modeling framework based on the Max-Min operator, including Weibull and exponential distributions, to cover both variable and constant failure behavior. Furthermore, order statistics are used in the model, enabling the analysis of the weakest or strongest components in the system. This approach allows for a more precise assessment of system reliability, especially under extreme conditions, and provides deeper insights for reliability-based design, risk analysis and lifecycle planning.

Keywords: Reliability, Max-Min, Exponential, Order statistics, Weibull

References

1. Bayramoglu, I., & Gebizlioglu, O. L. (2021). A Max-Min model of random variables in bivariate random sequences. *Journal of Computational and Applied Mathematics*.
2. Murthy, D. N. P., Xie, M., & Jiang, R. (2004). *Weibull Models*. Springer.
3. Barlow, R. E., & Proschan, F. (1975). *Statistical Theory of Reliability and Life Testing: Probability Models*. Holt, Rinehart and Winston.

Advisor: Prof. Dr. Ismihan BAYRAMOGLU

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Modeling and Comparing Pine Wilt Parasite Dynamics Using Shifted Pell–Lucas Polynomials: An Approach Based on Chebyshev and Runge–Kutta Method

Öykü Karasu[1]
[1]*Department of Mathematics, Izmir University of Economics, Izmir, Turkey*
oykukarasu35@gmail.com

Abstract:
This study focuses on the mathematical modeling of pine wilt disease, a fatal epidemic in coniferous forests caused by the pinewood nematode, which is transmitted via insect vectors.The original model is formulated as a system of nonlinear fractional-order differential equations involving the Atangana–Baleanu derivative in the Caputo sense. While the original paper approaches the system using the q-Homotopy Analysis Transform Method (q-HATM), our study provides an alternative numerical treatment. In our approach, a second-order ODE component capturing the core dynamics of parasite transmission is isolated and solved numerically using both the Chebyshev spectral method and the classical fourth-order Runge–Kutta method. Each method yields an independent numerical approximation. The resulting numerical solutions are then projected onto a shifted Pell–Lucas polynomial basis, enabling a unified spectral representation that facilitates direct analytical and graphical comparison. The aim is to evaluate the stability, accuracy, and computational advantages of these approaches while demonstrating the power of orthogonal polynomial bases for post-processing solutions of epidemic models. This comparative study highlights the interpretability, convergence characteristics, and numerical behavior of each method, while demonstrating the utility of orthogonal polynomial expansions in the modeling of real-world biological systems.

Keywords: pine wilt disease, parasite transmission modeling, fractional-order differential equations, Atangana–Baleanu derivative, epidemic dynamics, Chebyshev spectral method, Runge–Kutta method, Pell–Lucas polynomials, orthogonal polynomial expansions, numerical analysis, vector-borne plant epidemics, mathematical biology

References

1. Padmavathi, V. et al. (2022). Numerical Modeling and Symmetry Analysis of a Pine Wilt Disease Model Using the Mittag–Leffler Kernel. *Symmetry*, *14*(1067).
2. Boyd, J.P. (2001). *Chebyshev and Fourier Spectral Methods*. Dover Publications.
3. Butcher, J.C. (2016). *Numerical Methods for Ordinary Differential Equations*. Wiley.
4. El-Daou, M. (2012). Pell and Pell–Lucas polynomials: Properties and applications. *Applied Mathematics and Computation*, *218*(17), 8473–8480.
5. Singh, J. et al. (2019). New aspects of fractional Biswas–Milovic model with Mittag–Leffler law. *Mathematical Modelling of Natural Phenomena*, *14*, 303.

Advisor: Assoc. Prof. Dr. Sevin GÜMGÜM

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

A Numerical Approach for Solving SEARQ Model of Social Media Addiction

Selin MAVİ[1]
[1]*Izmir University of Economics, Department of Mathematics, Izmir, Turkey*
selin.mavi@std.ieu.edu.tr,

Abstract:
This study focuses on the SEARQ mathematical model for the spread of social media addiction within society and the contagion dynamics among individuals within a mathematical framework. This model is a compartmental epidemiological model that divides the population into five compartments: Susceptible, Exposed, Addicted, Recovered, Quit individuals. The model is a nonlinear system of ordinary differential equations. The model is approximately solved using the collocation method based on Boubaker polynomials. These polynomials allow the construction of series-based solutions that provide insight into the system's behavior over time. As there is no analytical solution available in the literature for this model,the efficiency of the method is verified by comparing the obtained approximate solutions with the results obtained from the Fourth-Order Runge-Kutta (RK4) method. The accuracy is examined by means of the residual error analysis. The results are given in graphics and tables. The simulations obtained by approximate solutions exhibit the dynamics of social media addiction. The residual error table confirms the robustness of the method.

Keywords: Boubaker Polynomial, Residual Error, Collocation Method.

References

1. Alemneh, H. T., & Alemu, N. Y. (2021). Mathematical modeling with optimal control analysis of social media addiction. *Infectious Disease Modelling*, *6*, 405–419.

2. Ali, A. S., Javeed, S., Faiz, Z., & Baleanu, D. (2024). Mathematical modelling, analysis and numerical simulation of social media addiction and depression. *PLoS ONE*, *19*(3), e0293807.

3. Maayaha, B., & Arqub, A. (2023). Hilbert approximate solutions and fractional geometric behaviors of a dynamical fractional model of social media addiction affirmed by the fractional Caputo differential operator. *Chaos, Solitons & Fractals: X*, *10*, 100092.

4. Maria, A., Elinora, B., Leonardus, O., & Fried, B. (2023). Mathematical modelling and simulation of social media addiction TikTok using SEI1I2R type model. *Jurnal Diferensial*, *5*(1), 43–55.

5. Kongson, J., Sudsutad, W., Thaiprayoon, C., Alzabut, J., & Tearnbucha, C. (2021). On analysis of a nonlinear fractional system for social media addiction involving Atangana–Baleanu–Caputo derivative. *Advances in Difference Equations*, *2021*, 356.

6. Rashid, S., Ashraf, R., & Bonyah, E. (2022). Nonlinear dynamics of the media addiction model using the fractal fractional derivative technique. *Complexity*, *2022*, 2140649.

Advisor: Asst. Prof. Demet ERSOY ÖZDEK

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Traffic Light Optimization for Urban Intersections Using Network Flow Modeling

Serhat Balık[1]
[1]*Department of Mathematics, Izmir University of Economics, Izmir, Turkey*
serhat.balik@std.ieu.edu.tr

Abstract:
This project presents a dynamic traffic flow optimization model for the Fahrettin Altay intersection in İzmir, Turkey, using Network Flow Modeling. As urban traffic congestion continues to grow, traditional fixed-time traffic light systems fail to adapt to varying traffic densities, leading to inefficiencies such as increased delays and fuel consumption. To address these issues, the proposed model formulates the intersection as a directed graph, where nodes represent traffic entry and exit points, and edges represent traffic flows. A mathematical model was developed that incorporates flow conservation and capacity constraints, based on traffic data obtained from the General Directorate of Highways (Karayolları Genel Müdürlüğü). The main goal of the model is to maximize total vehicle flow and improve overall traffic efficiency. The methodology integrates data collection with mathematical optimization, solved using MATLAB's linear programming functions. Preliminary simulation results demonstrate the model's effectiveness in optimizing traffic flows across key approaches, reducing congestion, and enhancing network performance. This study contributes to the development of scalable and data-driven traffic management solutions, offering practical applications for improving urban transportation systems. Future work will focus on applying the model to larger networks and integrating adaptive, real-time traffic control strategies to further enhance urban mobility.

Keywords: Traffic flow optimization; Network flow modeling; Urban transportation systems; MATLAB simulation; Traffic management solutions.

References

1. J. Lee, "Urban Traffic Flow Management and Congestion Control," *Transportation Research Part C: Emerging Technologies*, vol. 25, pp. 15-25, 2017.

2. Z. Zhan, "Dynamic Traffic Signal Control with Real-time Adaptive Adjustment," *International Journal of Intelligent Transportation Systems Research*, vol. 17, no. 4, pp. 220-230, 2019.

3. L. Zhang, H. L. Dong, and Q. Zhao, "Optimization of Traffic Signal Timings Using Particle Swarm Optimization," *Journal of Traffic and Transportation Engineering*, vol. 30, no. 6, pp. 1234-1241, 2020.

4. S. Chen and M. J. Saif, "Graph Theory Applications in Urban Traffic Flow Models," *Journal of Urban Traffic Management*, vol. 35, pp. 1120-1130, 2018.

Advisor: Prof. Dr. Gözde Yazgı TÜTÜNCÜ

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Spectral Modeling of Smoking Behavior Using Recursive Pell-Lucas Polynomial Approximations

Tuna Kutoğlu[1]
[1]*Izmir University of Economics, Department of Mathematics, Izmir, Turkey*
tuna.kutoglu@gmail.com

Abstract:

This paper examines the implementation of polynomials techniques utilizing Pell-Lucas polynomials to represent smoking behavior dynamics. The proposed model observes the flow between four key population segments: individuals who may begin smoking, those who smoke lightly, habitual smokers, and those who have successfully quit. While traditional numerical strategies like Runge-Kutta methods are commonly applied to differential systems, polynomials approaches using orthogonal polynomials can yield as accurate and rapidly converging results, particularly in nonlinear contexts.In this study, Pell-Lucas polynomials are adopted to form global polynomial solutions through a collocation-based strategy.Their structure contributes positively to numerical stability and performance, especially in systems characterized by complex temporal dynamics.Simulations performed across a variety of starting conditions highlight the advantages of the Pell-Lucas polynomials method, showing enhanced accuracy and reduced computational effort compared to standard finite difference approaches. These results affirm the potential of Pell-Lucas-based polynomials techniques in effectively describing the evolving patterns of smoking behavior. Furthermore, the flexibility and precision of this method suggest its relevance in broader domains such as epidemiology and behavioral modeling.

Keywords: Smoking Behavior, Pell-Lucas Polynomials, Spectral Approximation, Polynomial Methods.

References

1. Huo H-F, Zhu C-C. Influence of relapse in a giving up smoking model. *AbstrAppl Anal* 2013:525461, 12 pages.

2. Alzaid, S. S., Alkahtani, B. S. T. (2021). Asymptotic analysis of a giving up smoking model with relapse and harmonic mean type incidence rate. Results in Physics, 28, 104437

3. Rahman GU, Agarwal RP, Din Q. Mathematical analysis of giving up smoking model via harmonic mean type incidence rate. *Appl Math Comput* 2019;354:128–48.

Advisor: Assoc. Prof. Dr. Sevin GÜMGÜM

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Modeling Online Game Addiction Dynamics via Nonlinear SEIR Equations

Yaren Coşkunyürek[1]
[1]*Izmir University of Economics, Department of Mathematics, Izmir, Turkey*
yarencoskunyurek@outlook.com

Abstract:

This study investigates the numerical solution of a nonlinear SEIR model designed to examine online game addiction dynamics among junior high school students. Since the model lacks a closed-form analytical solution, a Bessel polynomial-based collocation method was employed.The Bessel polynomial method allows for direct treatment of the model's nonlinearities, eliminating the need for both time discretization and linearization, thereby offering a flexible and efficient alternative for solving complex dynamical systems. The resulting approximate solution was compared with the classical fourth-order Runge-Kutta (RK4) method to evaluate efficiency. Residual error analysis was also conducted to validate the consistency of the polynomial approach. Results are presented graphically, showing the time-dependent behavior of the Susceptible, Exposed, Infected, and Recovered compartments.

Keywords: SEIR Model, Online Game Addiction, Bessel Polynomial, Collocation Method, Runge-Kutta, Residual Error, Numerical Solution

References

1. Side, S., Saman, A., Pratama, M. I., Ramadhan, N. R., & Sanusi, W. (2021). *Numerical solution of the SEIR model for online game addiction problem by homotopy perturbation methods in students of junior high school*. Journal of Physics: Conference Series, *2123*(1), 012004. https://doi.org/10.1088/1742-6596/2123/1/012004

2. Anwar, A., Syam, R., Pratama, M. I., & Side, S. (2021). SEIRS model analysis for online game addiction problem of mathematics students. *Journal of Physics: Conference Series*, *1918*(4), 042024. https://doi.org/10.1088/1742-6596/1918/4/042024

3. Ascher, U. M., & Petzold, L. R. (1998). *Computer methods for ordinary differential equations and differential-algebraic equations*. SIAM.

4. Canuto, C., Hussaini, M. Y., Quarteroni, A., & Zang, T. A. (2007). *Spectral methods: Fundamentals in single domains*. Springer. https://doi.org/10.1007/978-3-540-30726-6

Advisor: Asst. Prof. Dr. Demet ERSOY ÖZDEK

Acknowledgements: This study was supported by TUBITAK 2209-A University Students Research Projects Support Program (Project No: 1919B012470946). We would like to thank TUBITAK for the support.

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Optimized team distribution in disaster situations using AHP and MILP methods

Ali Oğulyaymış[1] **, Yunus Emre Demirtaş**[1]
[1]*Department of Mathematics, Izmir University of Economics, Izmir, Türkiye*
ali.ogulyaymis@std.ieu.edu.tr, yunus.demirtas@std.ieu.edu.tr

Abstract:
In this study, our objective is to create different variants of optimization models for the planning of emergency response teams after an earthquake. In these models, our goal is to form optimized rescue teams that consider different scenarios that can occur during an intervention in an earthquake in Izmir. During the assignment of teams, variables such as the damage distribution and the level of damage in the districts affected by the earthquake were determined as optimization objectives. There are two different optimization methods. One of them is the Analytical Hierarchy Process (AHP) and the Mixed Integer Linear Programming (MILP) method. Relative risk values are given for all districts. These risk values are calculated according to the maximum-minimum normalization technique, where they vary between 1 and 10, and a classification is performed accordingly.

Keywords: Optimization, MILP, AHP, Disaster, Earthquake

References

1. INSARAG(2020).Volume II,Manual B-Operations.
https://insarag.org/methodology/insarag-guidelines/

2. Akdas, E.& Eren, T. (2023). Establishment of Search and Rescue Teams in Disaster and Emergency Management *Journal of Disaster and Risk*, *6*(3),
https://dergipark.org.tr/tr/pub/afet/issue/80195/1267389

3. Vaidya, O.S.& Kumar, S. (2006). Analytic hierarchy process: An overview of applications. *European Journal of Operational Research 169*1, (pp. 1-29).
https://doi.org/10.1016/j.ejor.2004.04.028

4. Wolsey, L.A. (1998). Integer Programming.
https://onlinelibrary.wiley.com/doi/book/10.1002/9781119606475

Advisor: Prof. Dr. Gözde Yazgı TÜTÜNCÜ

ISBN 978-625-6001-21-3

İZMİR UNIVERSITY OF ECONOMICS PRESS

I. Workshop on Applied Mathematics and Statistics May 10, 2025

Statistical Modeling of Industrial Machine Failures: Distribution Fitting and System Reliability Analysis

Yusuf Erol[1]
[1]*Mathematics, Izmir University of Economics, Türkiye*
yusuf.erol@std.izmirekonomi.edu.tr

Abstract:
This study analyzes the time-to-failure (TTF) behavior of Type L industrial machines drawn from the AI4I 2020 dataset. For each machine, the interval between consecutive failures was computed and used to fit four parametric distributions (Weibull, Lognormal, Exponential, Gamma) via maximum likelihood estimation. Model selection was guided by Akaike's Information Criterion and log-likelihood values, with the Lognormal distribution emerging as the best fit for most machines. We then derived and plotted key reliability metrics—survival function, failure probability, and hazard rate—and examined a 3-out-of-5 system configuration to illustrate how overall reliability degrades as individual machines fail. Finally, distribution fitting was repeated for the first ten machines and summarized in a comparative table. The results demonstrate that machine-specific modeling yields more accurate life-cycle insights and can inform optimized maintenance strategies.

Keywords: Time-to-Failure (TTF), Parametric Distribution Fitting, Maximum Likelihood Estimation, Akaike Information Criterion, System Reliability, Maintenance Planning

References

1. Kuru, B., Özdemir, C., & Yılmaz, B. (2020). AI4I 2020: Industrial Machine Learning Data Set. *UCI Machine Learning Repository*.
2. Gupta, A. K., & Nadarajah, S. (2004). *Handbook of Beta Distribution and Its Applications*. CRC Press.
3. Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control*, *19*(6), 716–723.
4. Rajan, J. (2005). *Reliability Engineering: Theory and Practice*. Springer.
5. Elsayed, E. A. (2012). *Reliability Engineering* (2nd ed.). Wiley.
6. Modarres, M., Kaminskiy, M., & Krivtsov, V. (2016). *Reliability Engineering and Risk Analysis* (3rd ed.). CRC Press.

Advisor: Assoc. Prof. Dr. Cemal Murat ÖZKUT