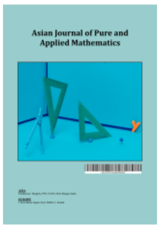

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Current Trends in Mathematics

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Authors' contributions

This work was carried out in collaboration between both authors. Author FZO did conception and interpretation of this study. Author MIO did design, execution and wrote the paper. Both authors read and approved the final manuscript.

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Original Research Article

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Abstract

Mathematics has been advancing in theory and applications. These applications have high impact on productivity and innovation. Recent advances have built strong bridges between different areas or subfields of mathematics. Through literature review of advances in mathematics, we present modern trends, including mathematical biology, uncertainties quantification, social networks, medicine and three-dimensional spaces. In mathematical biology, mathematics has enabled researchers to model biological processes, analyze relationships and patterns, optimize biological processes and interpret the complexities of biological systems. We have also revealed that mathematics supplies the statistical framework required to analyze and model uncertainties. Furthermore, in uncertainty quantification, mathematics investigates how variations in inputs affect outputs. Mathematical optimizations techniques help identify the best strategies or parameters that minimize risk or maximize performance while accounting for uncertainty. We have shown that through game theory, optimization, statistical analysis, machine learning and modeling dynamics, social networks have greatly benefited from mathematics. This research also revealed that mathematical algorithms, biostatistics, mathematical models, optimization, and decision theory have greatly added to the progress in medicine. Three-dimensional spaces have benefited from mathematics through vector calculus, coordinate systems, topology, optimization, 3D modeling, and geometric representations. These trends reveal practical applications of mathematics in the human society.

Keywords: Trends; mathematics; applications; advances.

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1 Introduction

The modern foundation for science, economics, engineering, and business is highly and strongly hinged on mathematics. According to Borzi, et. al. [1], mathematics is the utmost applied science and the most abstract art. They revealed that mathematics is becoming an increasingly essential and integral part of researches in biology, business, climate, social sciences, advanced design and many more.

In day to day life, mathematics is present, even when people don't realize they are using mathematical reasoning. Mathematical activities such as education and applications have changed a lot. Today, employing computer for mathematical research is greatly appreciated and this has helped to reveal the strength of mathematics in other sciences. Recent advances in mathematics provide great benefits for industry and technology, economic competitiveness and innovation, science and engineering, and natural security.

According to Tiwari [2], mathematics provides useful realworld approximations, and it has the advantage of controlling all factors, isolating variables of interest, and allowing us to perform experiments we would not be able to perform in nature. Tiwari referred to simple models as biology's "perfect crystals", a reference in which one can get straight-forward insight. As we explore the complexities of global changes in natural communities, mathematics provides a powerful tool for understanding life.

50 years ago witnessed developments in mathematics, computing and communication technologies, and these development have made it feasible for the discoveries in physical sciences, innovations and inventions in engineering and technology, and the achievements in life sciences and economics. Consequently, many new areas of mathematics emerged, and inactive areas have become active [3].

Dubey and Singh [3], revealed the following examples of fields where mathematics is emerging vital: mathematics for materials; security issues (mathematics for information and communication, mathematics for sensors, mobile communication as well as network protection); software reliability demands that needs mathematics for architecture, computer language, etc.; automated decision making (pattern analysis, spectral analysis, probability, and stochastic analysis); and future systems (lighter vehicles, ICBM Interceptors, smaller satellites, Hit before being Hit, super-efficient energy/power sources, secured wireless communication systems, modeling and simulations, automation and robotics.

2 Methodology

We present the areas of application of mathematics and thereafter, study the emerging advances in these areas. The traditional application areas of mathematics are biology, engineering and physics where ordinary and partial differential equations are well employed, but scientific advancement over the years has elevated mathematics to where other sciences employ advanced mathematical tools. For example, considering mathematical applications to biology, experts in combinatorics are more familiar with finding pattern and tracing consequences of flipping over substrings, which arises in genetic code. In physics, understanding basic statistical mechanics' models requires probability and graph theory. Quarks and elementary particles are very combinatorial.

Linear programming finds a giant expression in operations research and economics, and this depends on conditions of convexity and unlimited divisibility. Logical decisions lead to integer programming plus optimization models, which are interesting and practical mathematics areas. Computer science is another interesting application area of mathematics. Well-formulated, difficult, and important mathematical problems emerge in studying data bases, algorithms, computer security and cryptography. Discrete mathematics, probability, and formal logic play a major role in computer science.

Applied mathematics is making giant strides over the recent years, and the diversity of applications is speedily strengthening the flow of information between all branches of mathematics. The recent trend in mathematics reveals that all branches of mathematics are associated to the terminology "applied mathematics". We strongly encourage an adventure into the application "world" of mathematics. It will give one the feel of strength and influence of mathematical skills in this terrestrial ball.

3 Results and Discussion

3.1 Mathematical biology

Biology is an adventurous area for mathematics. One can refer to biology as the mathematics' "new physics". Biology is an area of great interest in science and has the maximum mathematical applications. Powerful tools are provided by mathematics to analyze biological systems, even the most complex of them. Ernst [4] and May [5] revealed that the journey of mathematical applications to biology started with the pioneering work of Lotka, Volterra, Nicholson, Bailey and others. Their works presented mathematical demonstrations of populations' temporal changes, and their equations were either difference equations or differential equations. According to Cohen [6], population models are exceedingly vital in understanding intricate real phenomena, such as population cycles, and we can explore the populations' stability by these models.

Decline in biodiversity has been traced to habitat loss, but the consequences on populations cannot be readily predicted because of lack of framework for that. But it is natural to think that a population would still exist, no matter how small. However, according to Tiwari [2], mathematical models predicted that further than a certain threshold level, the population becomes extinct. This region of existence of the population is what mathematicians refer to as the invariant region. At the threshold population level which is a critical value, the population is at the verge of extinction. Therefore, mathematics has enabled us to see that a continuous rise in the population size of species, especially, the predator species, might lead to the species' extinction. Predicting these extinction points is important in the management and preservation of the richly endowed biodiversity.

Ossaiugbo and Okposo [7], mathematically analyzed the human population in the presence of the pneumonia infectious disease. They revealed in the sensitivity analysis that the rate of transmission of pneumonia and the rate at which exposed individuals become infectious are the most sensitive parameters that one must take advantage of, in the management and elimination of the pneumonia disease. Tsetimi, Ossaiugbo and Atonuje [8] studied the effect of Covid-19 on pregnant women and non-pregnant women. They constructed a seven-compartment deterministic model to show if the stability of the disease-free equilibrium can be guaranteed by lowering the basic reproduction number below unity. This, they showed via the model's bifurcation analysis, and a forward bifurcation was revealed, which assured us that the basic reproduction number below unity is enough guarantee for the disease-free equilibrium's stability.

Tsetimi, Ossaiugbo and Atonuje [9] furthered the work of Ossaiugbo and Okposo [7] on pneumonia dynamics among the human population. In their work titled "On the optimal control analysis of pneumonia", they incorporated three control measures namely prevention, vaccination and treatment, into the basic mathematical model. The analysis and simulations showed that a combination of all the controls provides the finest intervention tactic for the disease's elimination. Marcus, Augustine, and Jonathan [10], Marcus, Augustine, Jonathan, and Ighomaro [11] further revealed a current trend in mathematics in modeling the co-infection dynamics of diseases.

3.2 Uncertainties quantification

Mathematics has grown into the stage of simulating physical and biological quantities via simulations and mathematical models. Simulations and models are vital, especially in production sectors. It gives one a clear picture of what is expected so that necessary corrections and adjustments can be made on time to avoid economic waste and lower the risk of life and properties loss. It should be noted that mathematical simulations and models are not all the time accurate. These can be due to imperfect inputs and parameter values, incomplete representation of the physical or biological quantity under consideration, discrete and approximate representation of continuous equations, too many and unnecessary elements or model parameters, etc.

Uncertainty quantification exists as a field in mathematics for resolving the above mentioned issues arising from mathematical simulations and modeling of physical and biological quantities. This field requires an interdisciplinary knowledge that cuts across all branches of mathematics such as differential equations, statistical researches, stochastic processes, approximation theory, time series, etc. Borzi, et al. [1] stated that the drive of uncertainty quantification is to develop techniques that augment present simulation methods with deterministic models which will bring us closer to reality. They added that another way to take into account uncertainty in deterministic models is to extend them by introducing stochastic terms, and to think that uncertainty quantification and stochastic theory will merge in a unique discipline.

3.3 Social networks

Networks' study is simply putting together different physical, social and mathematical disciplines as statistical mechanics, dynamical systems, graph theory, statistics, algebra, optimization, chaos theory, etc. Our world is currently pervaded by networks ranging from the activities of groups of animals or robots to communication and energy distribution. Borzi, et al. [1] opined that the appearance of online public networks is altering behavior in various contexts and allowing non-centralized collective phenomena and interaction among large groups. Many social networks' attributes are now clearly understood. Thanks to mathematical models. In recent time, mathematics has popped up a substantial volume of works that focused on the advancement of random-graph models which capture selected qualitative properties observed in large-scale network data. Shaveta [12] emphasized that linear algebra, calculus, Probability and Statistics, optimization, discrete mathematics, Information Theory and numerical methods are important for data science.

Mathematics has enabled us to detect the extent of a network's connectivity, which in parts of a population however distant, are connected via short paths. It should be noted that these small routes are stress-free to discover, and has brought about the attainment of decentralized search algorithms. Mathematical models are also developed for the spread of positive or negative behavioral changes in a social network. Influencing and understanding such contagion phenomena rest on the complexity and size of the public network. Mathematical models help to improve our understanding of these contagion phenomena and hence, enhance system performance. Machine learning has greatly improved social networks. Some recent works on machine learning include Hastie, Tibshirani and Wainwright [13], Shikhman and Müller [14]. Broderick, Gelman, Meager, Smith, Zheng [15] and Allen, Gan, and Zheng [16].

3.4 Application to medical field

Apart from employing basic arithmetic operations in drug production and prescription, medical practitioners also study the outcome of mathematical models, optimal controls and simulations in the management and elimination of any infectious disease. Medical practitioners find it easier to study simulation results arising from mathematical epidemiological researches, and employ same in production and prescription of relevant and effective drugs, especially in the case of a pandemic. They can also advise the affected population with the awareness of the high impact findings and contributions to knowledge of mathematical researchers.

One current trend in application areas of mathematics in medicine is found in optimization. Using radioactive "seeds" placement inside a tumor, prostate cancer's treatment with computational techniques and refined optimization modeling was achieved. This led to more reliable and safer treatment results. Here, the goal is to minimize from its target bounds, the dose level deviations at a given tumor point under certain constraints. The dosage of the radiation must be in a given interval, and any deviation from the dosage that is prescribed, should not exceed a certain percentage. The dosage should also support at least a certain percentage of the tumor, and the radioactive seeds to be used should be known. Additional technical constraints can also be employed. The main decision variables of the Mixed Integer Programming Problem are the radioactive seeds location in the tumor and a variable that shows if the given radiation was realized at precise sample points in the tumor [17]. Other recent works on the applications of mathematics in medicine include Puri and Kumar [18], Pybus, O'Dea and Brook [19], and Anguelov, et. al. [20].

3.5 Three-dimensional spaces

Different branches of mathematics focus on spaces and its structures. In geometry, spaces in which we can represent lines, shapes, tangent vectors, etc. are considered. We can differentiate in geometry, which brings about the concept of tangent vectors. One can easily represent a two-dimensional space and a three-dimensional space, but it should be noted that there exists no straight graphical demonstration of higher dimensional spaces. Higher dimensional spaces are only physical space's extensions. According to Borzi, et al. [1]. Poincaré asked an important question relating to a three-dimensional sphere, which Grigory Perelman succeeded answered in 2002. The three dimensional ball is located in a four-dimensional coordinate space as a group of four-dimensional unit length vectors, i.e.

$$x^2 + y^2 + z^2 + w^2 = 1$$

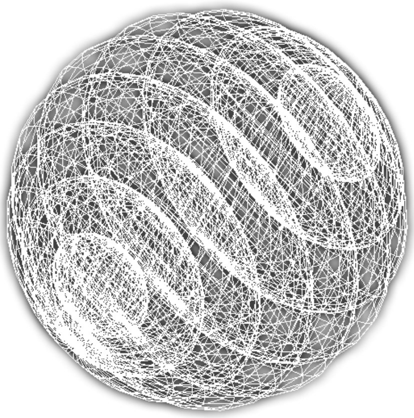

Fig. 1. The 3-D Sphere

Rada and Zamboj [21] stated that a classical ball (2-sphere) is set in a 3-dimensional Euclidean space. They further stated that in a higher dimension, a 3-sphere can be set in a 4-dimensional Euclidean space. Any path that is closed on the sphere might be deformed continuously through closed paths, and each time, remaining on the sphere, so that it can be shrunk down to a point. The question of Poincaré was simple: is the sphere the only finite extent geometrical entity, up to topological sameness, having this property?

Grigory Perelman employed profound ideas from geometry and analysis and focused on an idea of Hamilton on Ricci flow evolution equations and the singularities development. Various equations for various engineering and science systems, and other geometric problems, fit into this class, and as a result and by-product, the intertwining of the areas of differential geometry, topology and PDEs will take a huge impact.

4 Conclusion

Mathematics is a broad and an interesting field of study that finds application in all areas of life. In fact, mathematics is man's language. Every mathematics branch can be linked together with yet little or negligible divisions between them. These division lines inside mathematics are strongly being bridged in order to uncover more research opportunities for all disciplines. The current trend in mathematics strongly roots out mathematics from the abstract world into the practical world.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Competing interests

Authors have declared that no competing interests exist.

References

[1] Borzi A, Griesmaier R, Markert-Austch P, Schmidt S, Roy S, Schindele A, Wongkaew S, Sprengel M, Gaviraghi B, Ciaramella G, Merger J, Gathungu DK, Schmiedecke C, Rahman T. Trends in Mathematics. Institute for Mathematics, University of Würzburg, Wroclaw Center for Stochastic Computing; 2019.
Available:www.mathematik.uni-wuerzburg.de. Assessed 13th July, 2022.

[2] Tiwari M. A mathematical applications into the cells. Journal of Natural Science, Biology, and Medicine. 2012;3.
DOI:10.4103/0976-9668.95937. Pp. 19-23.

[3] Dubey M, Singh BK. Recent trends in mathematics and potential contribution to other disciplines. International Journal of Innovation and Research in Educational Sciences. 2014;1(2.):115-118.

[4] Ernst E. Complementary medicine: common misconceptions. J R Soc Med. 1995;88(5):244-7.

[5] May RM. Uses and abuses of mathematics in biology. Science. 2004;303:790-793.

[6] Cohen JE. Mathematics is biology's next microscope, Only Better; 'biology is mathematics' next physics, Only Better. PloS Biol. 2004;2(12): e439.

[7] Ossaiugbo and Okposo. Mathematical modeling and analysis of pneumonia infection dynamics. Science World Journal. 2021;16(2):73-80.

[8] Tsetimi, Ossaiugbo and Atonuje. Bifurcation Analysis of a Mathematical Model for the Covid-19 Infection among Pregnant and Non-Pregnant Women. European Journal of Pure and Applied Mathematics. 2022;15(2):537-556.
DOI: https://doi.org/10.29020/nybg.ejpam.v15i2.4312.

[9] Tsetimi, Ossaiugbo and Atonuje. On Optimal Control Analysis of Pneumonia. Universal Journal of Public Health. 2022;10(2):168-175.
DOI: 10.13189/ujph.2022.100203.

[10] Marcus OI, Augustine A, Jonathan T. A Co-infection Model for Monkeypox and HIV/AIDS: Sensitivity and Bifurcation Analyses. Journal of Scientific Research and Reports. 2024;30(5):351-368.

[11] Marcus OI, Augustine A, Jonathan T, Ighomaro ON. Mathematical formulation of a co-infection model and its analyses for monkeypox and HIV/AIDS infections. Asian Research Journal of Mathematics. 2024;20(3):12-39.

[12] Shaveta A. Role of mathematics in data science. The Northcap University; 2024. Available:https://www.ncuindia.edu/role-of-mathematics-in-data-science/.

[13] Hastie T, Tibshirani R, Wainwright M. Statistical learning with sparsity. Monographs on Statistics and Applied Probability. 2015;143(143):8.

[14] Shikhman V, Müller D. Mathematical foundations of big data analytics. Springer Gabler Berlin, Heidelberg; 2021. Available:https://doi.org/10.1007/978-3-662-62521-7.

[15] Broderick T, Gelman A, Meager R, Smith AL, Zheng T. Toward a taxonomy of trust for probabilistic machine learning. Sci. Adv. 2023;9:(7):eabn3999.

[16] Allen GI, Gan L, Zheng L. Interpretable machine learning for discovery: Statistical challenges and opportunities. Annual Review of Statistics and Its Application. 2024;11:97-121. Available:https://doi.org/10.1146/annurev-statistics-040120-030919.

[17] Eva KL, Marco Z. Operations research advances cancer therapeutics. Informs Journal on Applied Analytics. 2008;38(1):5-25. Available:https://doi.org/10.1287/inte.1070.0327.

[18] Puri A, Kumar S. A generalized order mixture model for tracing connectivity of white matter fascicles complexity in brain from diffusion MRI, Mathematical Medicine and Biology: A Journal of the IMA. 2023;40(3):223–237. Available:https://doi.org/10.1093/imammb/dqad002.

[19] Pybus HJ, O'Dea RD, Brook BS. A dynamical model of TGF-β activation in asthmatic airways, Mathematical Medicine and Biology: A Journal of the IMA. 2023;40(3):238–265. Available:https://doi.org/10.1093/imammb/dqad004.

[20] Anguelov R, Manjunath G, Phiri AE, Nyakudya TT, Bipath P, Serem JC, Hlophe YN. Quantifying assays: Inhibition of signalling pathways of cancer, Mathematical Medicine and Biology: A Journal of the IMA. 2023;40(3):266–290, Available:https://doi.org/10.1093/imammb/dqad005.

[21] Rada J, Zamboj M. 3-Sphere in a 4-Perspective. International Conference moNGeometrija; 2021. Available:https://www.researchgate.net/publication/354525053_3-Sphere_in_a_4-Perspective. Assessed 13th July, 2022.

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