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Shifting Paradigms in Nanotechnology: An Edas Assessment of Micro and Nanostructure Potential Across Disciplines Using EDAS Method

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Abstract: *This study presents a comprehensive analysis of micro and nanostructures across various fields using the Evaluation based on Distance from Average Solution (EDAS) method. The research evaluates five key areas: Electronics and Semiconductors, Medical and Biological Applications, Materials Science, Optics and Photonics, and Environmental Applications, across four primary domains: Electronics, Sensing, Energy, and Medicine. The EDAS method was employed to assess the performance and potential of micro and nanostructures in these fields. The analysis involved calculating Positive Distance from Average (PDA), Negative Distance from Average (NDA), and weighted values to determine the final rankings. Results indicate that Medical and Biological Applications rank highest, demonstrating the most significant potential and current applications for micro and nanostructures. Environmental Applications and Materials Science follow closely, ranking second and third respectively, highlighting their importance in addressing environmental challenges and advancing fundamental understanding of these technologies. Surprisingly, Electronics and Semiconductors, traditionally at the forefront of micro and nanostructure applications, ranked last among the evaluated fields. This unexpected outcome suggests a shift in the landscape of micro and nanostructure applications, with rapid advancements occurring in other areas. The study also reveals varying strengths across different domains for each field. For instance, Materials Science shows high relevance in Medicine, while Optics and Photonics excel in Sensing applications. This research provides valuable insights into the current state and future directions of micro and nanostructure applications. It emphasizes the growing importance of these technologies in medical, biological, and environmental applications, while also underscoring the need for continued research and development across all fields. The findings have implications for future research priorities, interdisciplinary collaborations, and potential industrial applications of micro and nanostructures.*

Keywords: *Materials Science, Biomedical application, Environmental technologies, Optics and Photonics, Semiconductor applications, Multi-criteria decision making, Nanotechnology evaluation and Interdisciplinary research.*

1. INTRODUCTION

The ultra-thin-body silicon-on-insulator (SOI) structure features a very thin silicon layer on top of the buried oxide layer, consisting of a single-crystal silicon device layer. This is particularly crucial for transistors. The thin silicon layer, coupled with low thermal conductivity, reduces the overall thermal conductivity of the layer, which prevents heat conduction generated during operation away from the active parts of the device. Integrated circuits typically use polycrystalline silicon films, such as those found in MOS devices, where they serve as gate electrodes in two-phase structures, intermediate conductors, high-value resistors in thin films, and holmic contacts for shallow junctions. Additionally, heat transfer in thin polymer films and doped polysilicon resistive temperature sensors are used to thermally read and write data, which impacts MEMS devices with silicon films, including AFM cantilevers [1]. Each term can be represented as a sum of two beams corresponding to the rising grating interference. To address this, a scale is built for each tap. The amplitude adjusts the position and duration of the appearance in the direction of the interval. One of the main principles of IL is to address the challenge of simple and reproducible recording between independent gratings. Currently, two approaches are used to handle this registration issue. The first approach involves limiting the number of beams used to ensure proper registration. The second approach uses a phase mask to create a set of beams and employs multiple expressions if necessary [2]. Bandgap engineering plays a crucial role in providing charge distribution and confinement, mixing electronic wave functions, and influencing carrier transport within semiconductor heterostructures. This is essential for the next generation of devices and technology. Traditional radio spectroscopy methods, which have low sensitivity and are inadequate for less-directional systems, face limitations due to low activity doses. However, these challenges can be addressed using optically detected magnetic resonance (ODMR). A limitation of the ODMR technique is that the transition rate between the magnetic field-split energy levels induced by microwaves must be comparable to or less than the energy difference between these levels, meaning the lifetime must be at least a few tens of microseconds. Level Ant crossing (LAC) spectroscopy does not have this limitation, as it is considered to be magnetic resonance at zero frequency [3]. In many cases, the particles act as fillers or modifiers, and their influence is determined by factors such as size, density, volume fraction, and gross features like shape. These materials are fully scalable and have various applications, including stimulants, cosmetics, drug and gene delivery, hydrogen manufacturing and storage, photonics, photovoltaics, and rechargeable batteries. In emerging applications, the chemical structure and distribution of matter within the particles are crucial in determining their function. For example, hollow structures with significant void space have been successfully utilized to enhance product output and control the delivery of drugs, cosmetics, and DNA [4]. Conductive polymer micro containers, when prepared in specific ways, exhibit unique morphologies that are beneficial for various applications. These micro containers have been shown to possess a high surface area. The process involves using CP (conductive polymers) and plasma shaping techniques. Initially, the electrode surface is pre-coated with non-conducting polymers. By designing these polymer micro containers and utilizing region-specific electrodeposition, immediate conductance can be achieved. Our latest work focuses on the development of polypyrrole micro containers. Here is a summary of the work, including both formatted and unformatted versions. We will also discuss their shaped and shapeless potential applications, particularly in the field of sensing [5]. Nanoscience and nanotechnology have garnered significant interest over the past decades, driven by rapid advancements in nanomaterials science. This progress is largely attributed to various microscope facilities, which have enabled scientists to observe and study nanostructures. These imaging and analytical capabilities, along with recent developments, have allowed for in situ investigation of the mechanical, composite, electrical, and other properties of nanostructures. Additionally, they facilitate high-resolution imaging and analysis under varying pressure and temperature conditions. Surface-sensitized inversion spectroscopic microscopy techniques employ X-ray sources to detect photoelectrons. These methods reveal a few surface layers of the model, facilitating the examination of sub micrometer longitudinal structures. The third-generation techniques available at synchrotron facilities require high-intensity and corrective X-rays for accurate analysis [6]. A distinctive feature of the structures to be measured is their size, which is comparable to the wavelength of light. In this context, dispersion and variance are applicable. The interaction between light and matter results in a characteristic shape of the contact electric field, which can be measured as a function of the reflection angle. Optical models of the structure can calculate this shape, providing precision well beyond the resolution limits of geometrical optics. Smaller structural parameters can be determined with greater accuracy. This method, however, is only applicable to fixed-term structures. Optical diffraction and dispersion measurements have been extensively used for a long time, including in goniometric and Fourier scatterometry [7]. In our prior research, we have explored biological structures, functionalized particles, and surface morphology. We have also reported on bio-defined formulations for manufacturing and bio-replicating methods that yield highly desirable structures and properties. Micro devices, which can be biological or constructed from nanostructures, are of particular interest. Single-cell diatoms, found abundantly in rivers, lakes, and other aquatic environments, exhibit a rapid reproductive rate. Their cell walls, known as frustules, are amorphous and consist of a transparent silica structure. The potential for frustration in academia has been thoroughly examined for its commercial applications. This has led to the development of numerous new theories and techniques, particularly in diatom-based bio-nanotechnology (or diatom nanotechnology), which has become an emerging field of research [8]. Recently, the development of Nano-sized nanoparticles has garnered significant interest. These structures are attractive for various reasons, including their nanostructured conductors, novel resistances, and unique electronic sensitivities. Additionally, molecules with biological recognition properties show potential as templates for linking. Various methods for utilizing metal nanoparticles are not limited to specific approaches. For instance, Chia and Brooke have created patterns on photoresist by immobilizing spin-coated silica nanoparticles, while Minelli et al. used block copolymer films visualized with plasma. Additionally, the combination of nanoscale phase separation and nanotechnology has been employed to produce adhesive areas with particle treatment. Techniques such as electron beam lithography and scanning probe lithography have also been applied to develop Nano patterned templates [9]. In recent years, numerous studies have focused on metallic cobalt nanoparticles, reporting various findings. Many of these nanoparticles exhibit oxidation when exposed to air or in solution. However, there is a lack of systematic studies on this subject. To enhance the efficiency of processes, especially in different research fields, it is crucial to investigate the oxidation phenomena of these nanoparticles both quantitatively and qualitatively. Additionally, there is a need for stabilization studies of the oxidation processes, as current practical information on structured materials is limited [10]. This article aims to address a critical need by creating micro- or nanometer-scale structures on surfaces. Tubular and spherical structures with specific features were developed through experimental methods, including embossing with mechanical deformation in elastic films. We report our combined efforts, using standard analyses and limited resources, to fabricate and bend element samples. Our findings demonstrate that we can make accurate assessments of the shape and form of these soft objects. This approach allows for precise control over the shape, dimensions, structure, loading patterns, and mechanical strains. The simplicity of our method shows great potential for replicating biological activities in future applications [11]. Unstained biological samples offer minimal differentiation in direct optical imaging. To identify various structures, biologists use fluorescent dyes. However, these dyes can be invasive, phototoxic, and prone to long-term bleaching. Therefore, it's advantageous to employ imaging techniques that visualize biological structures in their natural state. Since cells are nearly transparent, they minimally alter the amplitude of light passing through them but do affect its phase. Differential interference contrast (DIC) and phase contrast microscopes are particularly sensitive to these phase changes and are considered the gold standard for imaging stained cells. Recent advancements in holographic techniques provide three-dimensional phase information in a much more comprehensive manner. Optical reconstructions using digital holography allow for unique reproduction of features by regenerating material data from recorded light measurements [12]. For these purposes, protein constructs are adept at forming functional assemblies from modular components. Achieving aggregation involves finely dividing proteins for precise targeting in nanoscale structures. Protein immobilization is typically achieved through direct adsorption onto solid supports or via chemical reactions. Techniques such as photolithography, micro contact printing, piezo dispensing, or scanning probe microscopy are commonly employed for these purposes. Highly robust proteins like antibodies, when utilized in functional roles, often exhibit only a fraction of their active form available for analysis. Successful application in various contexts remains challenging due to the proteins' metastable nature and diverse physicochemical properties, complicating their secure attachment to solid supports [13]. This phenomenon involves selectively absorbing specific wavelengths of light, which causes scattering and enhances the local electromagnetic field. The resonant frequency of a plasmatic particle depends on the dielectric properties of both the metal and its surrounding medium, as well as the structural dimensions of the nanostructure. Consequently, precise control over the geometry can tailor the properties of Plasmon resonance, making it crucial for designing metallic nanostructures. To create Nano-optical devices focusing on nanostructures, bridging classical far-field optics with near-field interactions is crucial. One effective interface is through plasmatic nanoparticles, which can direct and control the propagation of light selectively. A promising approach begins with thin metal films that support surface Plasmon modes, transforming freely propagating light into bound states [14]. Previous research on micro- and nanostructures has effectively demonstrated super hydrophobic properties by reducing material surface energy. These super hydrophobic surfaces often undergo additional chemical modifications during manufacturing. While hydrophobic surfaces have been achieved in diverse materials, achieving highly ordered double structures for superior hydrophobic performance remains challenging due to the complexity and time-consuming nature of the required procedures. Therefore, there is a growing need for straightforward solutions to create highly ordered, high-performance hydrophobic double structures [15].

2. MATERIALS AND METHOD

Electronics and Semiconductors: A semiconductor falls between a conductor and an insulator in terms of electrical conductivity. It is essential in electronic equipment as it controls and manages the flow of electricity in devices. Consequently, semiconductors are widely used in computing accessories, various electronics, and solid-state storage, making them popular components in electronic chips developed for these devices.

Medical and Biological Applications: Biomedical applications include the diagnosis and treatment of various conditions, diseases, and defects, along with their respective countermeasures. Carbon, known for its biocompatibility, is often used in implants. Additionally, biocompatible polymer lattices are employed, sometimes in combination with other compounds, for these purposes.

Materials Science: Materials Science and Engineering focuses on the structure, transformation, and implementation of materials. It involves designing new materials and improving the properties of existing ones by identifying the best products available. This field also investigates why some materials unexpectedly fail and seeks to understand the fundamental behaviors and physical characteristics of materials.

Optics and Photonics: Optics is a wide-ranging field within physics that deals with the behavior and properties of light, as well as the study of vision and perception. Photonics, a sub-discipline of optics, focuses on the science and technology of photons. It is closely connected to quantum optics.

Environmental Applications: Environmental applications are a crucial field of study, as they help us understand the origins and functions of natural systems and their connections to the living world. Gaining knowledge in this area is essential.

Electronics: Electronics is a field derived from the study of electrons. It is a branch of physics that focuses on the behavior of electrons in various mediums such as vacuums, gases, or semiconductors. This discipline covers both the theoretical and practical aspects of electronic devices. The movement of electrons in these contexts occurs under the influence of applied electric and/or magnetic fields.

Sensing: Sensors play a crucial role in various aspects of our daily lives, including manufacturing, transportation, healthcare, and more. They capture physical parameters from the environment and convert these into signals, often in the form of pulses. These sensors come in various types, each suited for different applications. The data collected can be visualized to monitor and analyze different aspects of the environment or process.

Energy: The term "energy" originates from the Greek word Energeia, which was coined by Aristotle. The term was translated into English as "being at work," though there isn't a direct equivalent. Energy is often illustrated through analogies and is associated with concepts like power and strength, all of which imply the "ability to act." Unlike power and strength, which are more about capacity, energy specifically refers to the ability to expend or work and is related to the idea of transferability.

Medicine: Medicine focuses on patient care, including diagnosis, prognosis, prevention, and treatment of injuries and diseases. It is a practical science dedicated to optimizing health and improving outcomes through a thorough understanding of diseases. Medicine involves research and direct care aimed at enhancing the health of individuals and communities.

EDAS Method: This research aims to address this deficiency by employing Entropy-based EDAS for selection, utilizing state-of-the-art methodologies available in the market. The focus is on selecting electrified vehicles based on predefined criteria. The Entropy method is employed to determine the weights assigned to these criteria. This method is widely recognized for its simplicity and frequent application in evaluating differences between alternatives on a comparable scale, thereby playing a crucial role in decision-making processes [16]. Traditional single-model-based Estimation of Distribution Algorithms (EDAs) are effective for simple tasks but struggle with complex functions. To enhance their performance, consider viewing EDAs as a two-stage process: first, identifying promising regions within the search space that are globally optimized, and then refining the global optimum within these regions using local search. This approach ensures efficient exploration of the search space, utilizing probability models tailored to each region to guide local search efforts and achieve optimal algorithm performance. Each subpopulation represents a distinct sample in exploratory data analysis (EDA), termed as sub EDA. Additionally, it includes a specified number of individuals, each representing a solution within the search space. The integration of multiple sub EDAs into a comprehensive system is a characteristic feature of classical evolutionary algorithm (EA) methodologies. Each sub EDA autonomously manages resource allocation and control, primarily through crossover, mutation for exploration and exploitation of the search space, fostering communication and collaboration among subpopulations [17]. The aforementioned principles represent their own advantages and disadvantages, typically evaluated based on metrics such as energy savings, cache hit rate, and average access latency. However, a comprehensive evaluation considers multiple criteria rather than relying on a single measure like latency alone. In practical scenarios, determining the true effectiveness of these criteria poses challenges, particularly in Multi-Criteria Group Decision Making (MCGDM), where contextual complexity complicates the resolution of vague information. To address this, we propose the MCGDM-based EDAS method, which integrates a scoring function to combine target weight and composite weight, highlighting the benefits of robust fuzzy models [18]. Many of these bridges are old and formal in structure. They require no maintenance, which is crucial for modern society. These bridges are being renewed to accommodate traffic flow and meet contemporary needs. Preserving their historical significance is essential. Adequate materials and advanced technologies are necessary for their upkeep. Engineers and project managers meticulously plan and execute renovations, adhering to safety regulations and local development plans. It's not a simple task to achieve satisfactory results. Before any reconstruction begins, it's vital to consider both the structural safety and socio-economic importance of these historic bridges [19]. An important aspect of Estimation of Distribution Algorithms (EDAs) lies in their ability to learn and model the problem during search. A key feature of probabilistic modeling by EDAs is its utility in generating new solutions and uncovering previously unknown structural insights about the problem. Consequently, EDAs are not only perceived as optimization tools but also as simulators that enrich understanding of the problem domain. The effective utilization of information in probabilistic models depends on preprocessing techniques and visualization methods, which enhance the scale and quality of information extracted, thereby aiding in problem-solving and knowledge enhancement [20]. The models utilized in Evolutionary Data Analysis (EDAs) typically share similarities with those in the continuous case, featuring a sampled probability distribution. This distribution signifies an optimal one-gravity layer, implying that over time, an intriguing search algorithm will selectively retain portions and amalgamate them. However, EDAs employing multimodal distributions with models tend to be more intricate and consequently more susceptible to fragility. One significant issue in Evolutionary Data Algorithms (EDAs) is the rapid loss of algorithmic diversity, potentially leading to convergence on local optima. A straightforward method to enhance diversity in EDAs involves adjusting the model structure itself, thereby prompting changes within the model's scope. If exploration is confined to specific regions, algorithms may revert to prior parameters; otherwise, they may escape local optima. This approach, albeit dated, has been previously explored in research [21]. Understanding and acknowledging the established benefits of Evolutionary Data Algorithms (EDAs) on standard benchmark problems through experimental validation is crucial. Moreover, it is essential to extend this evaluation to non-synthetic benchmarks to gain insights into real-world applicability and performance. This approach also reflects significant research focus within the EDA literature, particularly in addressing probabilistic interactions among variables and practical issues like routing efficiency [22]. In DARTS, using operation weights directly for estimation during the search phase is impractical due to the one-shot framework. Instead, the optimal path in the grid is selected while pruning numerous paths. The one-shot network's superimposition results in significant discrepancies between its behavior during search and evaluation. Therefore, evaluating samples obtained during the search phase becomes crucial for assessing these intermediate architectures. Consequently, the newly developed network in DARTS requires iterative practice. We introduce a novel one-shot architecture search approach where only one edge within each cell is updated per iteration. Throughout execution, all candidate operations are considered for inclusion by removing one edge per cell, maintaining consistency across other edges, which execute a single operation per edge. The selection of operations for each edge is based on the optimal architectural parameters at that stage [23]. In enhanced enclosed regions, a modified backward search approach prevents erroneous entries. When choosing residual pathways, a feasibility detection process is implemented. This constitutes a regression search mechanism designed for lengthy numerical protein sequences, notably cutting down computational expenses. Experimental findings indicate that an upgraded regression method within the HP model effectively corrects for unfit individuals. Specifically, it surpasses the performance of the standard regression method with longer protein sequences, demonstrating substantial improvement correlating with sequence length [24]. The study initially employs the entropy method to determine the weighting of criteria and utilizes the EDAS system for ranking bank performance. The research findings significantly contribute to the literature. Firstly, the EDAS approach, a widely cited multi-criteria decision-making method, is innovatively applied. Secondly, banks are ranked based on their capital groups and financial activities. Lastly, the study analyzes a ten-year sample, providing valuable managerial, policy, and educational insights. The remainder of this study is organized as follows: The second section reviews studies conducted in Turkey and other countries on banks, focusing on multivariate decision-making methods. The third section outlines the research data and methodology. The fourth section summarizes the analysis and resulting findings. The final section presents the study's conclusion [25]. Characterizing the exploration of the search space in learned probabilistic models presents another crucial aspect of Evolutionary Distribution Algorithms (EDAs). This issue has garnered significant attention within the EDA community, particularly concerning the effective representation of problem spaces and understanding the methodologies for sampling. However, analyzing the interaction and structure of learned probabilistic models poses increasing challenges due to two primary reasons: the stochastic nature of the search process in EDAs and the inherent approximation and auxiliary structures employed in model learning methods [26]. To obtain a general solution, view the issue as a fundamental 'building block' defined explicitly as disorder for Genetic Algorithms (GAs). It's crucial to highlight its significance. Consequently, a heuristic research approach targeting this problem proposed shortcut operators based on associative learning. This initiative eventually addressed the building block disruption problem, endorsing EDAs as a prevalent method for managing the robustness of probabilistic graphical models. The theoretical underpinnings of EDAs swiftly advanced for analysis, establishing a firm basis that spurred further algorithmic development. Subsequent research indicated that Bayesian networks provided distinct approaches within the realm of EDAs, emerging nearly concurrently [27]. These potential solutions are linked to a probabilistic model used for updating parameters. Consequently, the subsequent exploration focuses on high-quality solutions moving towards a specific region in MRAS parameter updates. This update process involves reference models guided by a series of implicit probability models. In the MRAS method, we present an algorithmic instantiation where a sequence of reference samples serves as generalized models for estimating distribution means (EDAs) using a proportional sampling approach. Furthermore, a recently proposed cross-entropy (CE) technique has been introduced to enhance and analyze the method's characteristics. The reference sample framework can also be utilized to assess the efficiency of CE and EDAs across various domains in a continuous and integrated manner. The study demonstrates the universal applicability of the proposed algorithm and illustrates its performance through numerical experiments [28]. Environment for Distributed Adaptive Services (EDAS) is a user-accessible, grid-like platform designed for long-term service provision. It offers infrastructure such as webservers and source-code repositories, emphasizing scalability and resource-aware delivery of services. It supports autonomous processing and evolutionary capabilities, contrasting with traditional client-server models by adopting a fully peer-to-peer approach for distributed mobile objects. EDAS employs flexible service models that enable automated, dynamic resource management, ensuring availability and reducing administrative complexity to optimize resource utilization efficiently [29]. The primary challenge lies in effectively managing available capital for downsizing while simultaneously optimizing both profit and risk, a complex task involving multi-objective optimization. This issue stems from potentially conflicting goals, where optimal portfolios are Pareto-efficient. Each portfolio achieves the highest expected returns possible for a given level of risk, without exposing itself to unnecessary risk. The Markowitz mean-variance framework links the properties of interdependent random variables, defining portfolio risk based on return variability. Realistic constraints, reflecting market conditions or investor preferences, can further refine this model [30].

3. ANALYSIS AND DISCUSSION

TABLE 1. Micro and nanostructures

	Electronics	Sensing	Energy	Medicine
Electronics and Semiconductors	10.20	45.20	91.50	72.60
Medical and Biological Applications	50.10	10.10	31.60	12.30
Materials Science	40.60	75.30	41.70	92.60
Optics and Photonics	10.20	85.20	71.90	82.70
Environmental Applications	30.50	65.20	21.80	62.50

The table provides a comparative analysis of micro and nanostructures across five domains: Electronics, Sensing, Energy, and Medicine. In Electronics and Semiconductors, Energy shows the highest involvement (91.50) while Medicine has the least (72.60). Medical and Biological Applications Favor Electronics (50.10) over other fields, with Energy and Medicine being less prominent. Materials Science excels in Medicine (92.60) and falls behind in Sensing (41.70). Optics and Photonics are most engaged in Sensing (85.20) and least in Electronics (10.20). Environmental Applications show a balanced distribution, with Sensing (65.20) as a strong focus.

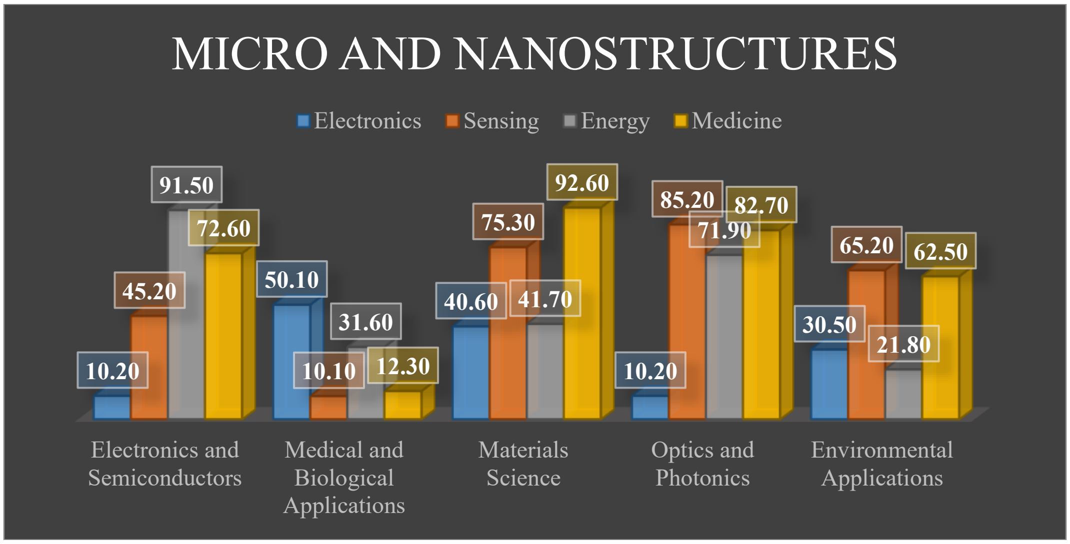

FIGURE 1. Micro and nanostructures

Figure 1 illustrates the distribution of micro and nanostructures across various fields. Energy is most prominent in Electronics and Semiconductors (91.50) and least in Medical and Biological Applications (31.60). Materials Science is highly relevant to Medicine (92.60), while Optics and Photonics excels in Sensing (85.20).

TABLE 2. Positive Distance from Average (PDA)

	Positive Distance from Average (PDA)			
Electronics and Semiconductors	0.00	0.00	0.00	0.00
Medical and Biological Applications	0.77	0.00	0.39	0.81
Materials Science	0.43	0.34	0.19	0.00
Optics and Photonics	0.00	0.52	0.00	0.00
Environmental Applications	0.08	0.16	0.58	0.03

Table 2 shows the Positive Distance from Average (PDA) for different EDAS methods across four fields. Electronics and Semiconductors have a PDA of 0.00 in all areas, indicating no deviation from the average. Medical and Biological Applications exhibit the highest PDA in Medicine (0.81) and moderate values elsewhere. Materials Science shows positive deviations in Electronics (0.43) and Sensing (0.34), but none in Medicine. Optics and Photonics have a notable PDA in Sensing (0.52) and zero in other fields. Environmental Applications show varied PDA, with the highest in Energy (0.58) and low values in other areas.

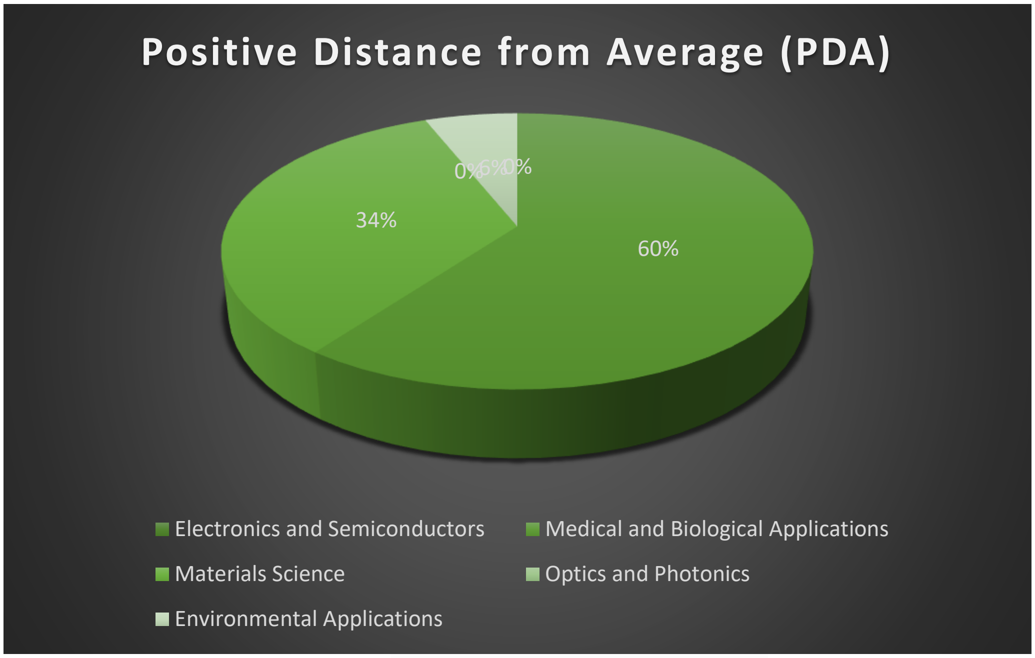

FIGURE 2. Positive Distance from Average (PDA)

Figure 2 depicts the Positive Distance from Average (PDA) for various EDAS methods. Electronics and Semiconductors have no deviation (0.00) across all fields. Medical and Biological Applications show notable PDAs in Medicine (0.81) and Sensing (0.77). Materials Science has moderate deviations, while Optics and Photonics mainly differ in Sensing (0.52). Environmental Applications exhibit varied PDAs, especially in Energy (0.58).

TABLE 3. Negative Distance from Average (NDA)

	Negative Distance from Average (NDA)			
Electronics and Semiconductors	0.63984	0.19573	0.76983	0.12488
Medical and Biological Applications	0.00000	0.82028	0.00000	0.00000
Materials Science	0.00000	0.00000	0.00000	0.43477
Optics and Photonics	0.63984	0.00000	0.39072	0.28138
Environmental Applications	0.00000	0.00000	0.00000	0.00000

Table 3 presents the Negative Distance from Average (NDA) for different EDAS methods across four fields. Electronics and Semiconductors have significant negative deviations, particularly in Energy (0.76983) and Sensing (0.19573). Medical and Biological Applications show a high NDA in Sensing (0.82028) but none in other areas. Materials Science has a notable negative deviation in Medicine (0.43477). Optics and Photonics display substantial NDA in Electronics (0.63984) and Energy (0.39072). Environmental Applications have no negative deviation across any field.

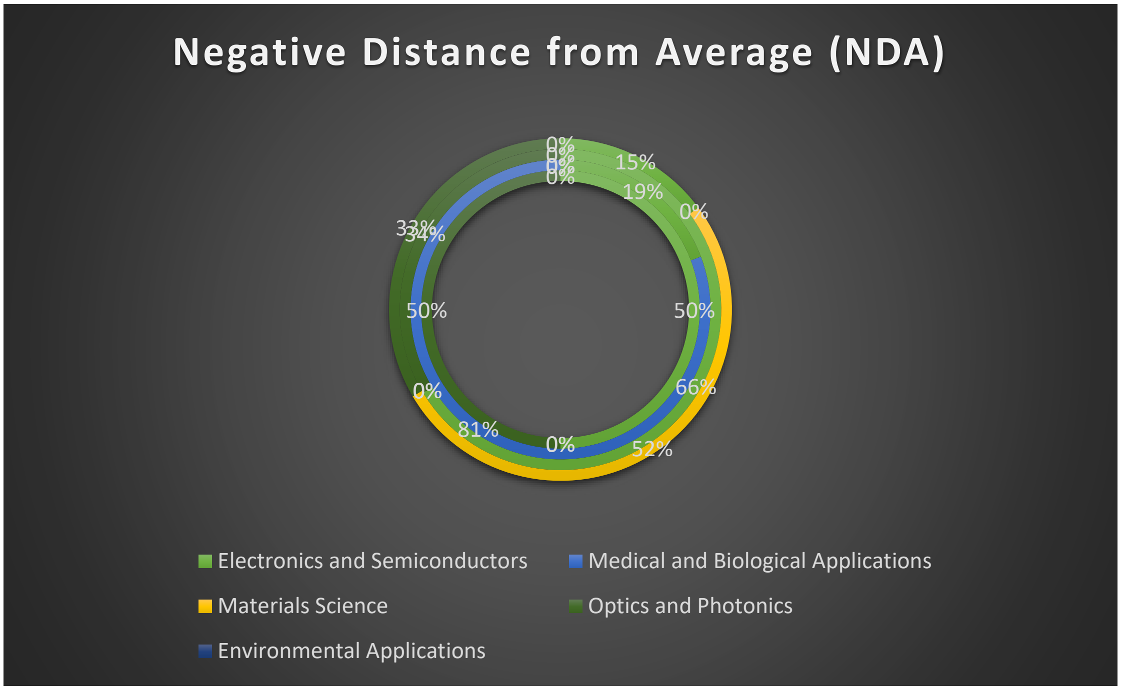

FIGURE 3. Negative Distance from Average (NDA)

Figure 3 illustrates the Negative Distance from Average (NDA) for various EDAS methods. Electronics and Semiconductors show notable negative deviations, especially in Energy (0.76983) and Electronics (0.63984). Medical and Biological Applications have a significant NDA in Sensing (0.82028) but none elsewhere. Materials Science has a specific negative deviation in Medicine (0.43477). Optics and Photonics exhibit notable negative deviations in Electronics (0.63984) and Energy (0.39072). Environmental Applications report no negative deviations across all fields.

TABLE 4. weightages

Weightages			
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25

Table 4 presents the weightages utilized within the EDAS method. Each variable is assigned equal weightage, denoted by 0.25 across all categories. This uniform distribution ensures an unbiased evaluation of variables, promoting fairness and consistency in the decision-making process. By employing standardized weightages, the EDAS method facilitates systematic and transparent analysis, enhancing the reliability of outcomes and recommendations.

TABLE 5. Weighted PDA SPi

Weighted PDA				SPi
0.00000	0.00000	0.00000	0.00000	0.00000
0.19229	0.00000	0.09720	0.20236	0.49184
0.10839	0.08496	0.04836	0.00000	0.24171
0.00000	0.12900	0.00000	0.00000	0.12900
0.01924	0.04004	0.14458	0.00790	0.21176

Table 5 displays the Weighted Positive Distance from Average (PDA) and SPi for different EDAS methods. Electronics and Semiconductors have a uniform PDA of 0.00000 across all fields, indicating no positive deviation. Medical and Biological Applications show the highest PDA in Energy (0.49184) and moderate values elsewhere. Materials Science has a notable PDA in Electronics (0.10839) and lower values in other areas. Optics and Photonics exhibit a significant PDA in Sensing (0.12900) and lower values in other fields. Environmental Applications show a varied PDA, with the highest in Energy (0.14458) and lower values elsewhere.

TABLE 6. Weighted PDA SNi

Weighted NDA				SNi
0.15996	0.04893	0.19246	0.03122	0.43257
0.00000	0.20507	0.00000	0.00000	0.20507
0.00000	0.00000	0.00000	0.10869	0.10869
0.15996	0.00000	0.09768	0.07034	0.32798
0.00000	0.00000	0.00000	0.00000	0.00000

Table 6 presents the Weighted Positive Distance from Average (PDA) and SNi for various EDAS methods. Electronics and Semiconductors have significant PDA with the highest SNi in Electronics (0.15996) and Energy (0.19246), indicating considerable positive deviation. Medical and Biological Applications show a notable SNi in Sensing (0.20507) but no deviations in other areas. Materials Science has a distinct SNi in Medicine (0.10869) and lower values elsewhere. Optics and Photonics display a notable SNi in Electronics (0.15996) and Energy (0.09768). Environmental Applications have no positive deviations, reflected by a zero SNi across all fields.

TABLE 7. Final Result of Micro and nanostructures

	NSPi	NSPi	ASi	Rank
Electronics and Semiconductors	0.00000	0.00000	0.00000	5
Medical and Biological Applications	1.00000	0.52592	0.76296	1
Materials Science	0.49145	0.74873	0.62009	3
Optics and Photonics	0.26229	0.24178	0.25203	4
Environmental Applications	0.43054	1.00000	0.71527	2

Table 7 shows the final results for micro and nanostructures, including NSPi, ASi, and rankings. Medical and Biological Applications rank highest with the highest NSPi (1.00000), ASi (0.76296), and overall rank of 1. Environmental Applications follows with a significant NSPi (0.43054) and ASi (0.71527), ranking 2nd. Materials Science ranks 3rd with a notable NSPi (0.49145) and ASi (0.62009). Optics and Photonics rank 4th with lower values for NSPi (0.26229) and ASi (0.25203). Electronics and Semiconductors, showing no significant deviation (0.00000) in both NSPi and ASi, are ranked 5th.

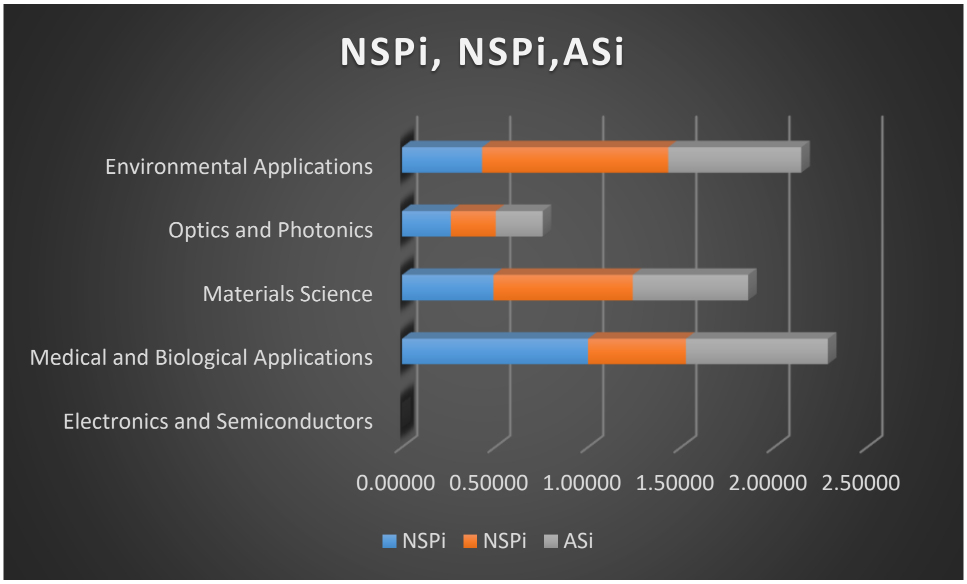

FIGURE 4. Final Result of Micro and nanostructures

Figure 4 presents the final results for micro and nanostructures, showing NSPi, ASi, and rankings. Medical and Biological Applications lead with the highest NSPi (1.00000) and ASi (0.76296). Environmental Applications follow with significant NSPi (0.43054) and ASi (0.71527). Materials Science has notable values with NSPi (0.49145) and ASi (0.62009). Optics and Photonics show lower values for NSPi (0.26229) and ASi (0.25203). Electronics and Semiconductors have zero values across NSPi and ASi, indicating the lowest performance.

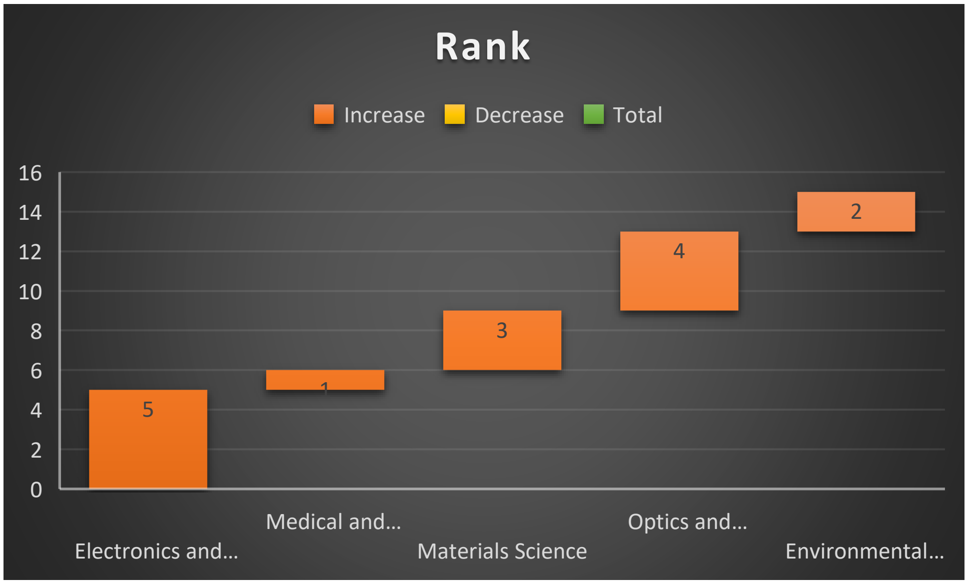

FIGURE 5. Shown the Rank

Figure 5 illustrates the rankings for various EDAS methods based on their final results. Medical and Biological Applications hold the top rank (1) due to the highest performance metrics. Environmental Applications are ranked 2nd, reflecting strong results in the evaluation. Materials Science is in 3rd place, indicating solid performance but not the highest. Optics and Photonics follow in 4th place, showing lower rankings compared to the top three. Electronics and Semiconductors are ranked 5th, with the lowest performance among the evaluated methods.

4. CONCLUSION

The study evaluated five key areas: Electronics and Semiconductors, Medical and Biological Applications, Materials Science, Optics and Photonics, and Environmental Applications. These were assessed across four primary domains: Electronics, Sensing, Energy, and Medicine. Medical and Biological Applications emerged as the top-ranked field, demonstrating the highest overall performance with the best NSPi (Normalized Positive Distance from Average) and ASi (Aggregated Score) values. This suggests that micro and nanostructures have particularly significant potential and current applications in medicine and biology, likely due to their ability to interact with biological systems at the cellular and molecular levels. Environmental Applications ranked second, indicating a strong and growing role for micro and nanostructures in addressing environmental challenges. This could include applications in areas such as water purification, air quality monitoring, and sustainable energy technologies. Materials Science secured the third position, highlighting its importance in the development and application of micro and nanostructures across various sectors. The field's strong performance underscores its crucial role in advancing the fundamental understanding and practical implementation of these technologies. Optics and Photonics ranked fourth, suggesting a significant but somewhat less dominant role in the current landscape of micro and nanostructure applications. However, its notable performance in the Sensing domain indicates potential for growth and innovation in areas such as advanced imaging and detection technologies. Surprisingly, Electronics and Semiconductors ranked last among the evaluated fields. This unexpected result may indicate that while this field has traditionally been at the forefront of micro and nanostructure applications, other areas are now rapidly advancing and finding diverse applications for these technologies. The analysis also revealed varying strengths across different domains for each field. For instance, Materials Science showed high relevance in Medicine, while Optics and Photonics excelled in Sensing. This diversity highlights the interdisciplinary nature of micro and nanostructure applications and the importance of cross-field collaborations. In conclusion, this study provides valuable insights into the current state and potential future directions of micro and nanostructure applications. It emphasizes the growing importance of these technologies in medical and biological applications, as well as in addressing environmental challenges. The results also underscore the need for continued research and development across all fields to fully harness the potential of micro and nanostructures. As these technologies continue to evolve, we can expect to see even more innovative applications emerging, potentially reshaping various industries and scientific disciplines in the coming years.

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