KAKATIYA INSTITUTE OF TECHNOLOGY & SCIENCE
Warangal – 506 015, Telangana, INDIA *(An Autonomous Institute under Kakatiya University, Warangal)*
కాకతీయ సాంకేతిక విజ్ఞాన శాస్త్ర విద్యాలయం వరంగల్ – ౫౦౬౦౧౫.

ELECTROMANIA

A Technical Magazine

VOL-XIII

Academic Year: 2023-2024

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Vision of the Department

- Develop the department into a full-pledged center of learning in various fields of Electronic and Communication Engineering in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society.

Mission of the Department

- Imparting quality education to develop innovative and entrepreneurial professionals fit for the globally competitive environment.
- To nurture the students in the field of Electronics and Communication Engineering with an overall back-ground suitable for attaining a successful career in higher education, research and Industry

Program Educational Objectives (PEOs) of the Department

The PEO's of the B. Tech (Electronics and Communication Engineering) program are focused on making our graduates technologically superior and ethically strong

PEO-I: Building on fundamental knowledge, graduate should continue develop technical skills within and across disciplines in Electronics and Communication Engineering for productive and successful career maintaining professional ethics

PEO-II: Graduates should develop and exercise their capabilities to demonstrate their creativity in engineering practice and team work with increasing responsibility and leadership

PEO-III: Graduates should refine their knowledge and skills to attain professional competence through lifelong learning such as higher education, advanced degrees and professional activities

Program Outcomes (POs) of the Department

Engineering program must demonstrate that their students attain the following outcomes:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs) of the Department

PSO1: Readiness for immediate professional practice.

PSO2: An ability to use fundamental knowledge to investigate new and emerging technologies leading to innovations.

EDITORIAL BOARD

Principal Message

I'm delighted with the initiative taken by the Department of Electronics & Communication Engineering in launching ELECTROMANIA, a technical magazine dedicated to the department. This publication promises to provide insights into the latest engineering trends and their piratical applications in industry and science. Through ELECTROMANIA, students will have the opportunity to improve their technical skills by engaging in discussions about the latest developments in science and technology. I am confident that this magazine will be warmly welcomed by both the student body and faculty members.

- Prof. K. Ashoka Reddy

Principal

Editor In-Charge Message

We are pleased to announce the release of volume-XIII of "ELECTROMANIA," the magazine published by the Department of Electronics & Communication Engineering. I extend my congratulations to the Faculty Editorial Board and the student members for their remarkable efforts in bringing forth this edition. The research articles contributed by both faculty and students across various domains will serve as a valuable resource for the student community, aiding them in staying updated with the latest advancements. It is my hope that this will provide students with exposure to cutting-edge technologies and enhance opportunities for research and work in core areas. With the support of the Management and Principal, the Department of ECE has recently established new labs.

- Dr. M. Raju

HoD,ECE

Faculty In-Charge Message

We are delighted to announce the release of volume-XIII of "ELECTROMANIA," a technical magazine by the Department of Electronics & Communication Engineering. This publication will be a valuable resource for students, providing them with updates on the latest developments and helping them stay connected with advancements in the field. The fast-paced evolution of technology offers students opportunities to enhance their technical skills across various domains. We extend our gratitude to the student members for their innovative contributions to this endeavor.

- Sri S. Pradeep Kumar, Asst. Prof.

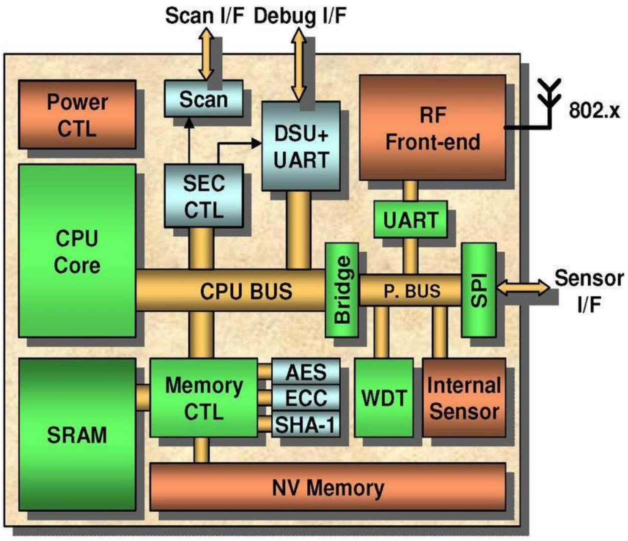
- Dr. M. Chandrashekar , Asst. Prof.

CONTENTS

WHAT TO LEARN

System-on-Chip (SoC)

System-on-Chip (SoC) is a revolutionary integrated circuit that condenses all necessary electronic components for a fully operational system onto a single chip. These components encompass the CPU, GPU, interfaces, potential cellular communication methods, and other critical elements, ensuring compactness, efficiency, and streamlined production processes.At the core of an SoC are its processor cores, which can range from microcontrollers to digital signal processors (DSPs), utilizing Reduced Instruction Set Computing (RISC) architectures like ARM for optimized performance, lower power consumption, and reduced board area. Memory is a vital component, encompassing various types such as ROM, RAM (comprising faster Static RAM (SRAM) and more economical Dynamic RAM (DRAM)), and flash memory, forming a hierarchical structure to meet diverse processing needs.SoCs interface with the external world via a suite of external interfaces supporting communication protocols like USB, Ethernet, and HDMI, as well as wireless standards such as Bluetooth and Wi-Fi. Supporting circuitry within SoCs includes voltage regulators, power management circuits, timing elements like phase-locked loops, clocks, oscillators, power-on reset generators, and analog-to-digital converters (ADCs), ensuring efficient and stable operation.



Embedded systems, a key application domain for SoCs, blend hardware and software tailored for specific functionalities, from simple, single-task devices to those with sophisticated graphical user interfaces (GUIs) like smartphones. The embedded market is forecasted to burgeon, reaching $116.2 billion by 2025, propelled by investments in artificial intelligence (AI), mobile computing, and the demand for high-performance processing. Notable chip manufacturers for embedded systems include industry giants like Apple, IBM, Intel, and Texas Instruments, underlining the sector's significance and growth potential.

Quantum technology

Quantum technology operates on the fundamental principles of quantum mechanics, such as quantum entanglement and superposition, which govern the behavior of sub-atomic particles. While our smartphones utilize quantum physics in their semiconductor technology, neither

The end-users nor the engineers necessarily delve deeply into the intricacies of quantum mechanics. However, the spotlight on quantum technology has intensified in recent years, despite its inception into our lives about half a century ago alongside nuclear power. This heightened attention is due to the latest advancements in engineering, which are progressively unlocking more of quantum mechanics' potential. Today, we are on the brink of actively manipulating quantum entanglement and superposition. Consequently, quantum technology holds the promise of enhancing a broad spectrum of everyday devices.For instance, it can bolster the reliability of navigation and timing systems, fortify the security of communication networks, refine healthcare imaging precision through quantum sensing applications, and propel computing capabilities to unprecedented heights. This evolving landscape underscores the transformative impact quantum technology is poised to exert across various domains, heralding a new era of innovation and functionality in our technological ecosystem.

Edge computing

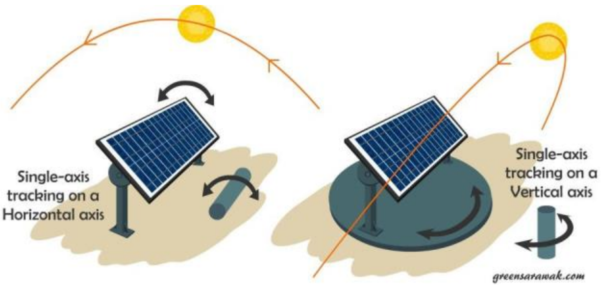
Edge computing, an emerging computing paradigm, involves a spectrum of networks and devices positioned near or at the user's vicinity.It focuses on processing data in close proximity to its source, enhancing processing speed and capacity, thereby yielding immediate actionable outcomes. Compared to traditional centralized computing models reliant on on-premise data centers, edge computing offers distinct advantages. Placing computational power at the edge enables organizations to optimize asset management, foster innovative human interactions, and cultivate real-time actionability. Various applications leverage edge computing, including self-driving vehicles, autonomous robotics, intelligent equipment monitoring, and automated retail systems. Key components of edge computing encompass edge devices, which encompass everyday gadgets like smart speakers, watches, and smartphones, capable of locally gathering and processing data. Additionally, Internet of Things (IoT) devices, point of sales (POS) systems, robotic platforms, vehicles, and sensors can serve as edge devices, they conduct local computation and communicate with cloud services.

The network edge, although not mandating a distinct "edge network," facilitates edge computing by serving as an intermediary between users and the cloud. With the advent of 5G technology, the network edge becomes pivotal, delivering robust wireless connectivity with minimal latency and high cellular speeds.

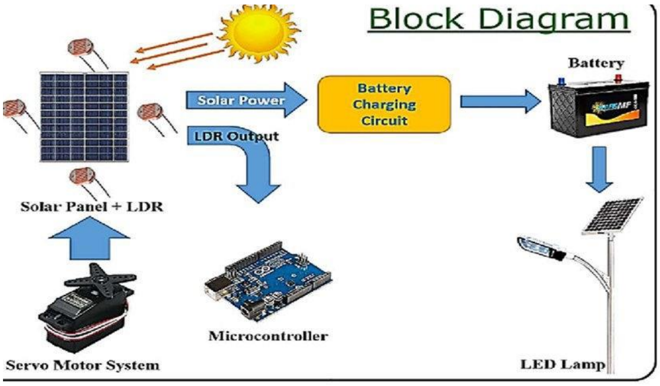
WHAT'S TRENDING NOW

Automatic Solar Tracking System

An automatic solar tracking system adjusts the position of solar panels or photovoltaic (PV) arrays to optimize sunlight exposure throughout the day, enhancing energy capture and solar power generation efficiency. Key features include sensors that detect sunlight intensity and direction, providing input to the controller. This controller, often a microcontroller or computer-based system, processes sensor data and commands actuators—such as electric motors or servo motors—to orient the panels perpendicular to the sun's rays. Sophisticated tracking algorithms predict the sun's position based on geographic location and time, ensuring precise panel alignment..



Mounted on sturdy structures, these panels utilize single-axis or dual-axis trackers for movement. Benefits of such systems include increased energy output, with potential boosts of 25-40% compared to fixed panels, leading to improved efficiency in solar energy utilization. Despite higher initial costs, automatic solar tracking systems offer cost-effectiveness over the long term, with faster payback periods and greater returns on investment.



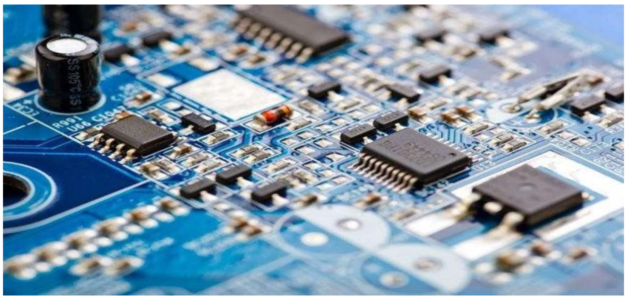
Blockchain

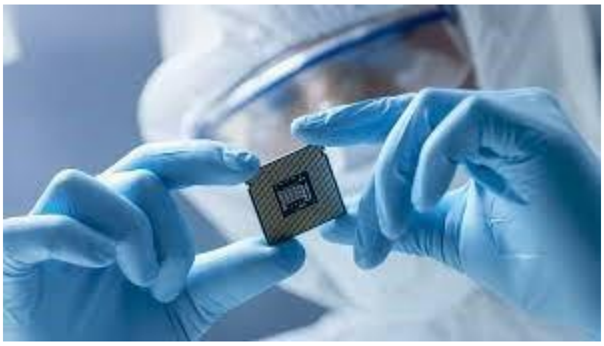
Blockchain, a decentralized and distributed ledger technology, ensures the security, transparency, and immutability of data by recording transactions across multiple computers. Data is stored in blocks, each containing transaction records. In Supply Chain Management, blockchain enhances transparency and traceability in the electronics industry by securely recording each step of the manufacturing and distribution process. This reduces the risk of counterfeit components and improves overall supply chain efficiency.

For Internet of Things (IoT), blockchain offers decentralized and tamper-proof recording of device data and transactions, enhancing privacy, security, and reliability in applications like smart homes and industrial automation. In secure transactions, blockchain enables peer-to-peer transactions without intermediaries, using cryptocurrencies like Bitcoin and Ethereum. Smart contracts automate and enforce transaction terms, reducing fraud risks. Smart contracts automate and enforce transaction terms, reducing fraud risks. Decentralized systems benefit from blockchain, distributing data and control across networks instead of centralized servers. This fosters innovation in distributed energy grids, decentralized organizations, and peer - to- peer marketplaces in electronics. Overall, blockchain technology revolutionizes the electronics industry by providing secure, transparent, and decentralized solutions for supply chain management, IoT, secure transactions, and decentralized systems. As blockchain adoption grows, its impact on electronics is expected to expand significantly.

Nano Technology

Nanoelectronics involves studying, designing, and applying electronic components and devices at the nanoscale, typically less than 100 nanometres. It explores materials like carbon nanotubes, graphene, and quantum dots, which offer unique properties for high-performance devices. Nanoelectronics enables miniaturization, leading to denser integration, lowerpower consumption, and faster operation, crucial for smaller and more efficient electronic systems. Advanced manufacturing techniques such as nanolithography and self-assembly produce complex nanoscale structures, essential for next-gen devices. Applications span computing, communication, healthcare, and energy, with nanoscale transistors and memory devices enhancing speed and storage density, and nanosensors monitoring biological and environmental parameters.





Challenges include reliability and scalability, addressed through material science and device physics advancements. Nanoelectronics promises breakthroughs in technology, driving innovation across sectors

WHAT'S NEXT ?

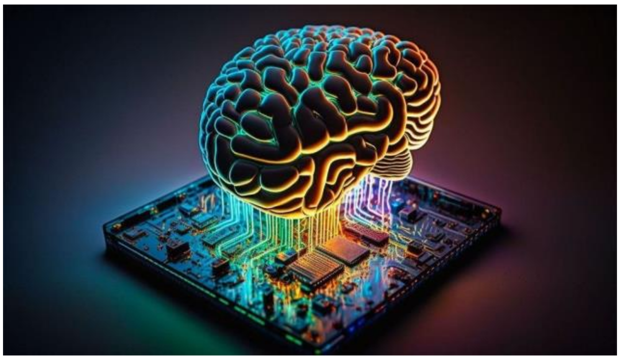
AI Integration

AI is no longer just a concept from science fiction; it's becoming an integral part of our daily lives, reshaping the technological landscape. Its integration opens up new possibilities, changing how we interact with machines and how machines interact with the world. In everyday applications, AI-driven voice assistants like Siri and Alexa simplify tasks such as setting reminders and controlling smart home devices. Facial recognition technology, powered by AI, enhances security and authentication, while recommendation systems personalize content on streaming platforms and e-commerce websites. In healthcare, AI aids diagnostics through image analysis, improving early disease detection. It also accelerates drug discovery, reducing time and costs associated with medication development.

industries, AI enables predictive maintenance by analyzing sensor data to minimize downtime. Robotic process automation automates routine tasks, boosting efficiency.However, challenges such as bias in AI systems and ensuring transparency and accountability in decision-making processes need to be addressed. Efforts are underway to promote fairness and establish clear guidelines for AI ethics.

Neuromorphic Engineering

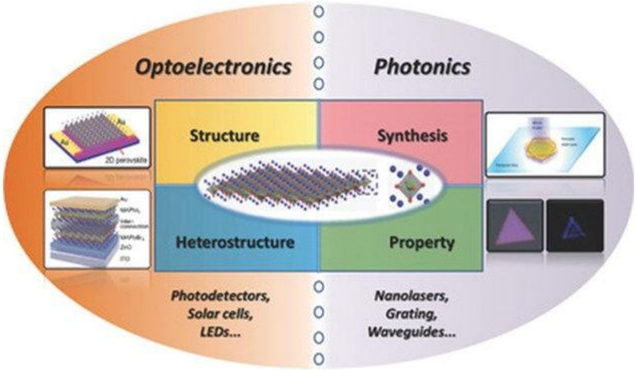
Neuromorphic engineering, a multi disciplinary field, draws inspiration from the human brain to design artificial neural systems. It aims to emulate the brain's parallel processing, learning, and adaptability. Researchers replicate neural circuits to create brain-inspired computing systems, resulting in neuromorphic chips that mimic biological neurons and synapses. Unlike traditional artificial neural networks, neuromorphic systems often implement spiking neural networks, communicating through discrete spikes. These systems excel at parallel processing, distributing computation across interconnected nodes efficiently.



Operating on an event-driven model, they respond to specific events similar to the brain's focus on relevant information. Neuromorphic systems exhibit unsupervised learning, adapting to patterns in data without explicit instruction. They find applications in sensory processing, such as vision, and contribute to energy-efficient AI development through neuromorphic computing.Additionally, neuromorphic software frameworks enable simulation and experimentation with neuromorphic models , while brain-computer interfaces facilitate direct brain-device communication. Current research delves into new architectures, materials, and algorithms to tackle scalability, task optimization, and system robustness, with neuromorphic engineering leading towards more efficientcomputing.

Photonics and optoelectronics

Photonics and optoelectronics are interdisciplinary fields studying light and its interaction with electronic devices, crucial in technologies like telecommunications and medical imaging. Photonics involves generating, detecting, and manipulating photons, encompassing lasers, optics , and imaging . Optoelectronics focuses on using light for generating, detecting, and controlling electronic signals, employing devices converting electrical signals into light and vice versa.Key technologies include lasers, pivotal for various applications, fiber optics enabling high-speed data transmission, and optical sensors measuring physical properties. Photonic Integrated Circuits (PICs) integrate multiple photonic components for efficient optical communication, while optical imaging plays a vital role in cameras and medical devices. Applications span telecommunications, where optical fibres form the internet backbone, and medical technologies like endoscopy and laser surgeries. Lasers find use in material processing, providing precision in manufacturing, while optoelectronic sensors monitor environmental parameters.



Emerging technologies include quantum photonics for quantum communication and computing, metamaterials with engineered optical properties, and photonic computing for faster and energyefficient dataprocessing. Challenges include developing cost-effective components, integrating photonics with electronics, and mitigating signal loss in optical communication. Photonics and optoelectronics continually evolve, shaping modern technologies from communication networks to medical diagnostics.

PERSONALITIES WHO MADE A DIFFERENCE

Ramalingam Chellappa

Ramalingam "Rama" Chellappa (Ranked # 56 in the World , # 39 in the Nation), a college park professor in electrical and computer engineering (ECE) is a pioneer in facial recognition technology. An internationally recognized expert in computer vision, machine learning, pattern recognition and artificial intelligence, Chellappa's work has had an impact on areas including biometrics, smart cars, forensics, and 2D and 3D modelling of faces, objects, and terrain and has a range of applications—including medicine. Chellappa has been a faculty member of the University for 29 years and served as chair of the department of ECE from 2011-2018 and as the Director of Centre for Automation Research for 12 years. A Fellow of IEEE, IAPR, OSA, AAAS, ACM, AAAI and NAI, Chellappa holds eight patents. He is currently the Bloomberg Distinguished Professor in the Departments of Electrical and Computer Engineering and Biomedical Engineering (School of Medicine) at Johns Hopkins. Chellappa has received many awards from IEEE, the International Association of Pattern Recognition, and the University of Maryland.

Dinesh Manocha

Dinesh Manocha (Ranked # 76 in the World , # 51 in the Nation), is a Distinguished University Professor of the University of Maryland, where he is the Paul Chrisman Iribe Professor of Computer Science and Professor of Electrical and Computer Engineering. He is also affiliated with the Institute for Systems Research and the Robotics Center. He is also the Phi Delta Theta/Matthew Mason Distinguished Professor Emeritus of Computer Science at the University of North Carolina at Chapel Hill. Manocha's research focuses on AI and robotics, computer graphics, augmented/virtual reality, and scientific computing. He co-leads a major research group UMD GAMMA with more than 25 members on geometric and simulation algorithms with applications to computer graphics, robotics, affective computing, and virtual environments. A Fellow of AAAI, AAAS, ACM, IEEE and the Sloan foundation, Manocha is a member of the ACM SIGGRAPH Academy, and a Bézier Award recipient from the Solid Modeling Association. Manocha was also the co-founder of Impulsonic, a developer of physics- based audio simulation technologies, which was acquired by Valve Inc in November 2016.

K. J. Ray Liu

K. J. Ray Liu stands as a luminary figure in the realm of academia, occupying the esteemed position of Distinguished University Professor at the University of Maryland. Within this institution, he assumes the prestigious role of the Christine Kim Eminent Professor of Information Technology, a testament to his profound contributions to the field. Boasting a remarkable global standing, Liu's name is synonymous with excellence, as evidenced by his impressive rank of #273 in the world and #177 nationally.

Liu's illustrious career is adorned with numerous accolades, reflecting his unparalleled expertise and dedication to the advancement of knowledge. Among his most notable achievements are two IEEE Technical Field Awards: the coveted 2021 IEEE Fourier Award for Signal Processing and the esteemed 2016 IEEE Leon K. Kirchmayer Graduate Teaching Award. Additionally, Liu has been honored with the IEEE Signal Processing Society 2009 Technical Achievement Award and the 2014 Society Award, underscoring his profound impact on the discipline. A trailblazer in his field, Liu's contributions have been recognized through over a dozen best paper and invention awards, attesting to the significance of his research endeavours. Furthermore, his status as a Highly Cited Researcher by the prestigious Web of Science serves as a testament to the endur-ing influence of his work. In recognition of his exceptional contributions, Liu has been elected as a fellow of esteemed organizations such as IEEE, AAAS, and the U.S. National Academy of Inventors, further cementing his status as a leading figure in the academic community. His ascension to the role of 2021 IEEE President-Elect underscores his unwavering commitment to driving innovation and excellence in the realm of information technology. Through his exemplary leadership and scholarly pursuits, K. J. Ray Liu continues to leave an indelible mark on academia, inspiring future generations to push the boundaries of knowledge and discovery.

Career Prospects

Exploring Career Paths after B.Tech in Electronics and Communication Engineering (ECE)

Embarking on a journey post-B.Tech ECE opens up a plethora of avenues, spanning across core job roles, non-core opportunities, government positions, entrepreneurial ventures, and further academic pursuits. Let's delve deeper into each category:

Core Job Opportunities after B.Tech ECE

Upon completing their undergraduate studies, ECE graduates often gravitate towards core job roles, primarily within companies directly involved in the electronics sector. These companies, though relatively scarce, offer enticing prospects for those with a specialized background. Noteworthy organizations in this domain include Semiconductors, Alstom Corporate, Bharat Heavy Electricals, Havells, Crompton Greaves, Neolex Cables, HBM Power Systems, and Exide Industries, among others. However, it's crucial to acknowledge the competitive landscape within these firms. Despite the allure of core positions, vacancies may be limited, with instances where suitable openings are scarce. Nonetheless, roles such as Design Engineer, ASIC Engineer Trainee, Jr. Embedded Engineer, or Network Support Engineer remain viable options. These positions grant access to diverse fields such as circuit design, wireless communications, robotics, VLSI, NanoTechnology, Embedded Systems, and more.

Non-Core Jobs (Across Various Fields) after B. Tech ECE

For individuals encountering challenges in securing core positions, exploring non-core opportunities becomes imperative. The software industry emerges as a fertile ground, offering roles where technical expertise in electronics is not mandatory. Instead, proficiency in programming languages such as C/C++ and strong communication skills take precedence. Leading private sector entities including Wipro, Tata Consultancy Services, Accenture, Infosys, HCL, and Genpact extend employment opportunities to ECE graduates. Roles such as Assistant Software Engineer, Junior Software Engineer, Programmer, Net Engineer, and Quality Analyst are frequently available. These positions come with competitive pay scales and often include benefits and perks.

Government Jobs after B. Tech ECE

Government positions represent another avenue for B.Tech ECE graduates. Recruitment for these roles typically occurs through exams conducted by the Public Service Commission of India. Public sector undertakings (PSUs) such as BSNL, MTNL, ISRO, BHEL, ONGC, and SAIL regularly hire technicians and engineers. Additionally, financial institutions like

IBPS and SBI offer employment opportunities for engineering graduates across various roles.Keeping abreast of recruitment schedules and updates via official websites is essential for aspiring candidates seeking government positions. Furthermore, opportunities exist in sectors beyond telecommunications, including defense, education, and more.

Entrepreneurial Ventures after B.Tech ECE

While venturing into entrepreneurship entails inherent risks, it presents an avenue for B.Tech ECE graduates to leverage their knowledge and skills. Despite the relatively low number of startups in the ECE industry, establishing a venture in domains such as VLSI, Robotics, Nanotechnology, Optical Communication, and Embedded Systems remains viable.Success in entrepreneurship hinges on meticulous planning, strategic execution, and a willingness to persevere through challenges. Those with innovative ideas and a strong work ethic stand poised to carve a niche for themselves in the competitive startup landscape.

Higher Education Pursuits after B.Tech ECE

For individuals inclined towards further academic pursuits, options such as pursuing postgraduate studies offer avenues for career advancement and specialization. Programs including M.Tech, Ph.D., M.S., and MBA enable graduates to augment their skill sets, broaden their horizons, and enhance their employability. Thorough research into various courses and institutions, considering factors such as faculty expertise, research facilities, and industry connections, is imperative before embarking on a journey of higher education. By strategically aligning their academic pursuits with career objectives, B. Tech ECE graduates can unlock a myriad of opportunities and chart a fulfilling career trajectory.

PROJECTS

"LIBRARY MANAGEMENT SYSTEM "

The Library Management System (LMS) is a computer-based application designed to efficiently store and manage the details of students and books in a library. It utilizes Java Database Connectivity (JDBC) and SQL to provide a robust mechanism for storing, accessing, and manipulating data. This project aims to enhance students' coding skills in Java, as well as their understanding of database management through practical implementation. The primary objective of the project is to develop an LMS that allows users to effortlessly manage library data. By automating these processes, the system aims to reduce clerical work, improve efficiency, and provide faster access to information. The project employs JDBC and SQL to establish connectivity between the Java pro-gram and the database. The following steps outline the process:

1. Import Packages: Necessary packages are imported to facilitate database connectivity within the Java program.
2. Load Drivers: The appropriate drivers, such as the Oracle JDBC driver, are loaded using Class.forName() or Driver Manager. Register Driver().
3. Register Drivers: The drivers are registered with the Driver Manager to enable database connection.
4. Establish Connection: A connection to the database is established using the Connection class object, specifying the URL, username, and password.
5. Create Statement: A statement object is created to execute SQL quries.
6. Execute Query: SQL queries are executed to perform database operations.
7. Close Connection: Finally, the connection is closed to release resources.

-By S. Advik Patel (B21EC012)

K. Poojith Harshan (B21EC033)

SIMPLE BANKING SYSTEM

The Simple Banking System project represents a fundamental yet crucial application aimed at efficiently managing user account details within a database. Developed using Java programming language, this project serves as a practical exercise for students to enhance their coding skills and gain a deeper understanding of database management principles. By implementing this project, students delve into various aspects of software development, including user input handling, data validation, database connectivity, and transaction processing.At its core, the Simple Banking System is designed to provide users with a seamless banking experience while ensuring the security and integrity of their financial information. The project revolves around the concept of creating a user-friendly interface that allows users to perform essential banking operations such as account creation, balance inquiries, deposits, and withdrawals. Through practical implementation, students explore the intricacies of programming logic, algorithm design, and error handling, thereby honing their problem-solving abilities and enhancing their coding proficiency.The choice of Java programming language for this project stems from its widespread adoption and versatility in software development. Java is renowned for its simplicity, platform independence, and robustness, making it an ideal choice for developing scalable and reliable applications. By working on a Java-based project, students not only reinforce their understanding of core programming concepts but also gain exposure to industry-standard tools and practices, preparing them for future endeavors in software development. The primary objective of the Simple Banking System project is to develop an intuitive and efficient banking application that caters to the diverse needs of users. Through a combination of textual prompts and menu-driven options, users can input their account details, perform banking transactions, and receive timely updates on their account

-By Y. Sai Nishitha (B21EC009)

BLOOD BANK

The blood bank is an application which maintains the blood records of patients. A computerized blood bank is provided which reduces manual and paper work. It provides an efficient and secured way for faster data entry, retrieval and data access.The blood bank system is an application for storing the details of person's blood efficiently in the database. A computer- based management system with database is designed to store the details of the user.The system will provide the set of services like blood group, pincode according to the user's requirements and also checks the existence of the user in the database. The reason why I have taken course project in Java programming is because it is one of the important programming languages for every student which helps us to increase the coding skills in Java. By doing this project we will experience the real use of syntaxes and concepts, So that we gain grip on many concepts of Java programming language which is further useful for handling projects in future.

PROBLEM DEFINITION

When in an emergency situation of a patient, who needs an emergency blood it is Hard to find in less time. It may results in death. So this online blood bank will instantly shows the details of blood donors, thus it can saves life of a person. The main objective of the project is to bridge the gap between blood donors and acceptors. we will display the donor details. Details of those registered with us, to be useful for people who are searching for blood donors.

Algorithm:

Step 1: START

Step 2: A donor can login with username and password.

Step 3: if he/she does not have any user name and password new donor login page will be opened.

Step 3.1: Now taking the donor details like blood group, pincode, district pincode,mail id.

Step 4: Storing the details of donor in Oracle

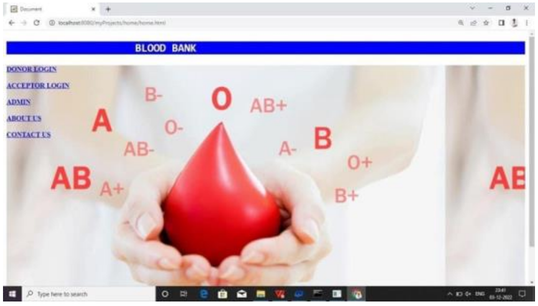
Step 5 : A acceptor can login with username and password.

Step 6: if he/she does not have any user name and password new acceptor login page will be opened.

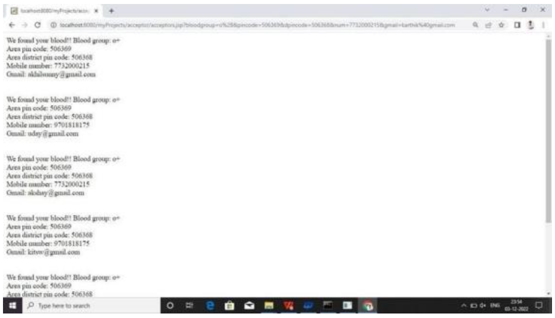
Step 7: Now taking the acceptor details like blood group, pincode, district pincode,mail id.

Step 8: Checking the donor and acceptor details and comparing the blood group.

Step 9: If details match showing the details of donor.



Finally: The design and development of this project provides a well-organized and secured approach for giving donor details. And by this project a blood acceptor can easily and quickly gets the donor details without any paperwork and user friendly.



- By Ch. Akhil(B21EC017)

TECHNOLOGY THE NEW AGE PROBLEM SOLVER

Robotics:

The field of robotics is experiencing rapid advancements, with robots being developed for an ever-expanding array of applications. From industrial manufacturing and logistics to healthcare and personal assistance, robots are increasingly utilized to perform tasks that are hazardous, repetitive, or beyond the capabilities of humans. One of the most exciting frontiers in robotics lies in the development of humanoid robots, designed to mimic human appearance and behavior, thereby facilitating seamless interaction and collaboration with humans in diverse environments. Recent advancements in robotics have propelled the development of highly dexterous and adaptable robots capable of navigating complex

Virtual Reality (VR);

Virtual reality has emerged as a transformative technology, offering immersive experiences that transcend the boundaries of physical reality. While VR has been in existence for decades, recent advancements in hardware and software have propelled its widespread adoption across various industries and domains. In the realm of entertainment, VR enables users to escape into virtual worlds, interact with digital environments, and experience visceral sensations that blur the line between fiction and reality. Beyond entertainment, VR holds immense potential for training, education, and simulation. From medical training and surgical simulations to virtual classrooms and corporate training programs, VR empowers users to learn and practice in safe, controlled environments, fostering experiential learning and skill development. Furthermore, VR is revolutionizing fields such as architecture, urban planning, and tourism by enabling virtual exploration and visualization of complex structures and environments.

TECHNOLOGY NEWS

In the ever-evolving landscape of technology, each passing year brings forth groundbreaking advancements that reshape our lives. Recent years have witnessed the dawn of a new technological era characterized by remarkable breakthroughs in artificial intelligence, robotics, virtual reality, and the internet of things. In this comprehensive exploration, we delve into the realms of these exciting new technologies, examining their applications, advancements, and potential implications for the future.

"Breakthroughs in Quantum Dot Displays Propel Creation of Ultra-High-Definition Screens, Elevating Color Accuracy to Unprecedented Levels"

In a significant stride towards visual perfection, quantum dot display technology has achieved a milestone in the realm of screen quality. Recent advances in quantum dot displays have ushered in a new era of ultra-high definition screens, characterized by unparalleled color accuracy and vibrancy. At the heart of this technological breakthrough lies the integration of quantum dots – nanoscale semiconductor particles – into display panels. These quantum dots possess unique optical properties, enabling precise control over the emission of light across the visible spectrum. By harnessing quantum effects, display manufacturer scan achieve exquisite color reproduction and fidelity that surpasses traditional LCD and OLED screens. The result is a visual experience characterized by lifelike hues, deeper blacks, and brighter whites, delivering images with stunning clarity and realism. With quantum dot displays, viewers can immerse themselves in a world of breathtaking detail. One of the key advantages of quantum dot displays is their ability to achieve a wider color gamut, covering a broader range of colors than conventional display technologies. This expanded color palette translates into more accurate representation of real-world scenes, ensuring that images appear true to life with every shade faithfully reproduced. Furthermore, quantum dot displays offer enhanced energy efficiency and longevity compared to traditional LCD and OLED screens. By minimizing power consumption and reducing the risk of image burn-in, these displays provide both environmental benefits and cost savings over their operational lifetime. As advancements in quantum dot technology continue to push the boundaries of display quality, the potential applications are vast and diverse. From high-end televisions and professional monitors to mobile devices and augmented reality headsets, quantum dot displays promise to revolutionize the way we perceive and interact with digital content. In the quest for visual excellence, quantum dot displays stand at the forefront of innovation, offering a glimpse into a future where every pixel is a masterpiece of color and clarity. With each advancement, the boundaries of display technology are pushed ever closer to perfection, ensuring that the quest for visual fidelity continues unabated.

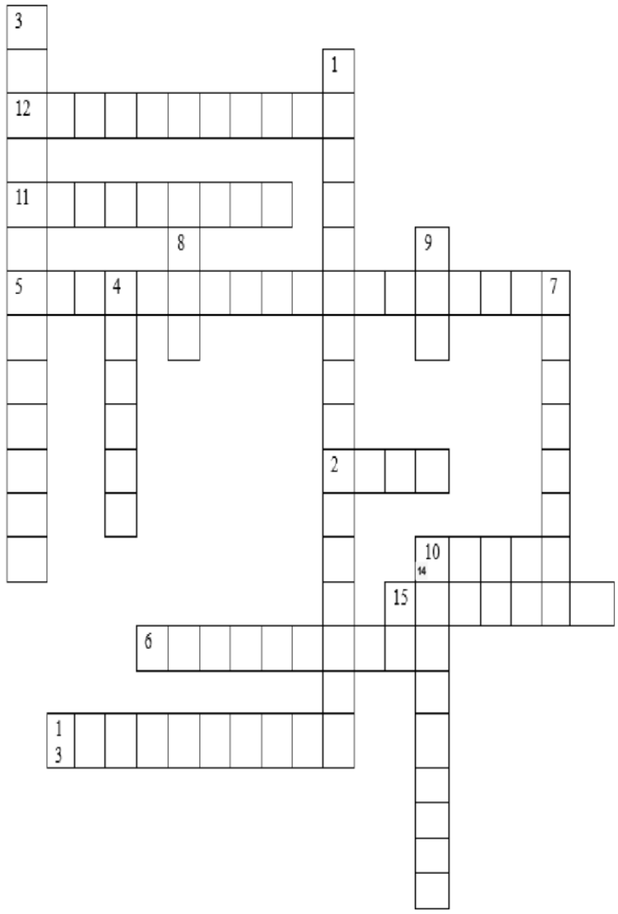
"AI-Powered Smart Antenna Systems Revolutionize Wireless Communication, Amplifying Coverage and Capacity"

In a groundbreaking leap forward for wireless communication, AI-driven smart antenna systems have emerged as a transformative force, poised to redefine the landscape of connectivity. These innovative systems, imbued with the intelligence of artificial intelligence algorithms, herald a new era of enhanced coverage and capacity in wireless networks. Traditionally, wireless communication has been constrained by the limitations of static antenna configurations, which struggle to adapt to dynamic environmental conditions and user demands. However, with the integration of AI capabilities, smart antenna systems transcend these constraints, dynamically optimizing signal transmission and reception in real time. At the core of these advancements lies the ability of AI algorithms to analyse vast amounts of data and make informed decisions to maximize performance. By continuously monitoring the wireless environment, including factors such as signal strength, interference, and user mobility, AI-powered smart antennas adapt their beamforming patterns and transmission parameters to optimize signal quality and coverage. The impact of AI-driven smart antenna systems is profound, unlocking a multitude of benefits for both consumers and network operators. Users experience improved signal reliability, faster data rates, and reduced latency, enhancing their overall wireless experience. Meanwhile, operators benefit from Increased network efficiency, enhanced spectrum utilization, and the ability to accommodate growing demands for data intensive applications. From urban environments with dense user populations to remote rural areas with challenging terrain, AI-powered smart antennas prove invaluable in extending coverage and capacity to previously underserved regions. Furthermore, their ability to dynamically adapt to changing conditions ensures resilience in the face of interference and network congestion. As research and development in AI-driven smart antenna technology continue to accelerate, the future of wireless communication shines brightly. With the promise of even greater performance enhancements and scalability, these revolutionary systems are poised to shape the next generation of wireless networks, ushering in an era of ubiquitous connectivity and seamless communication experiences for all. "Advancements in Neuromorphic Computing Propel Development of Brain-Inspired AI Chips, Revolutionizing Processing Efficiency" In the rapidly evolving landscape of artificial intelligence, groundbreaking progress in neuromorphic computing has sparked a transformative leap forward. Researchers and engineers have achieved remarkable milestones in the development of brain-inspired AI chips, heralding a new era of unparalleled processing efficiency. Drawing inspiration from the intricate architecture and functionality of the human brain, these innovative chips mimic the parallel processing and adaptive learning capabilities of neural networks. By leveraging principles of neurobiology, such as synaptic plasticity and spiking neural networks, these advanced AI chips demonstrate unprecedented levels of computational prowess.The integration of neuromorphic computing principles into and the ability to accommodate growing demands for data - intensive applications. From urban environments with dense user populations to remote rural areas with challenging terrain, AIpowered smart antennas prove invaluable in extending coverage and capacity to previously underserved regions. Furthermore, their ability to dynamically adapt to changing conditions ensures resilience in the face of interference and network congestion. As research and development in AI-driven smart antenna technology continue to accelerate, the future of wireless communication shines brightly. With the promise of even greater performance enhancements and scalability, these revolutionary systems are poised to shape the next generation of wireless networks, ushering in an era of ubiquitous connectivity and seamless communication experiences for all.

"Advancements in Neuromorphic Computing Propel Development of Brain-Inspired AI Chips, Revolutionizing Processing Efficiency"

In the rapidly evolving landscape of artificial intelligence, groundbreaking progress in neuromorphic computing has sparked a transformative leap forward. Researchers and engineers have achieved remarkable milestones in the development of brain-inspired AI chips, heralding a new era of unparalleled processing efficiency. Drawing inspiration from the intricate architecture and functionality of the human brain, these innovative chips mimic the parallel processing and adaptive learning capabilities of neural networks. By leveraging principles of neurobiology, such as synaptic plasticity and spiking neural networks,vanced AI chips demonstrate unprecedented levels of computational prowess.The integration of neuromorphic computing principles into Additionally, AI-powered chatbots are increasingly prevalent, revolutionizing customer service and support by automating interactions Despite its transformative potential, AI also raises ethical and societal concerns, including issues related to privacy, bias, and the displacement of human labor. As AI continues to perme- ate various aspects of daily life, it is im- perative to address these challenges and ensure that its benefits are equitably dis- tributed while mitigating potential risks.

ELECTRONIC PUZZLE



ACROSS:

2) A basic component of electronic device.

5) An electronic circuit that generates a sinusoidal waveform, typically in the radio frequency.

6) It is scenario consistently increasing and never decreasing or vice versa.

10) A word which is used in medical science as well as in waves.

11) A storage space for units of memory that are used to transfer data for immediate use by the CPU.

12) When________materials are placed in an electric field, practically no current flows in them.

13) It is a vector operator that operates on a vector field producing a scalar field.

15) The expected value of a real function of a random variable is

DOWN:

1) For attenuation of high frequencies we should use_____

3) A SCR is a________switch.

4) It stimulates and analyse your analog and mixed signal circuits within ORCAD.

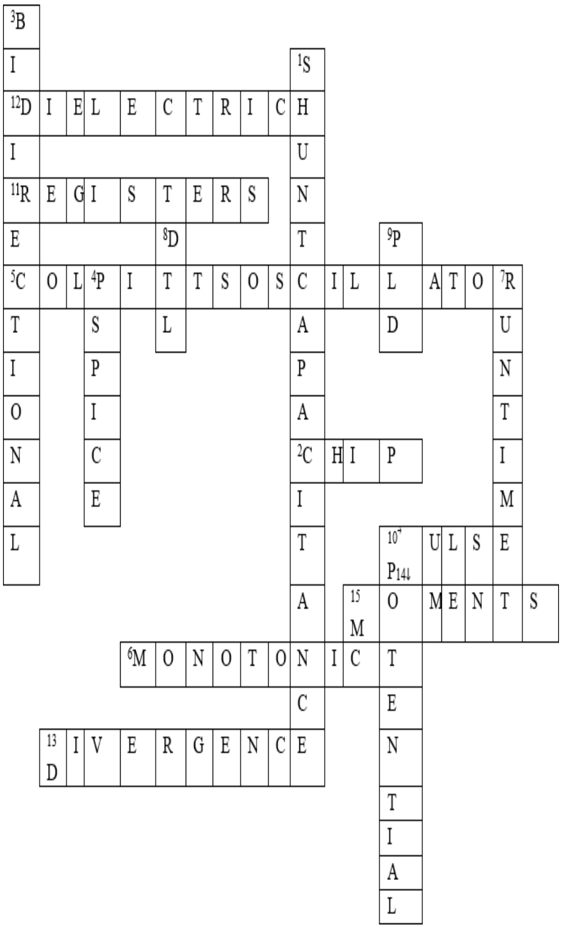
7) In which polymorphism, the compiler resolves the object at runtime, and then it decides which function call should be associated with that object?

8) A logic family which has high fanout and a slower speed.

9) One of the simplest programming technologies is to use fuses.

14) The amount of work done to move a unit positive charge from an infinitely long distance to that point.

ANSWERS


BIDIRECTIONAL
SHUNT CAPACITANCE
DIELECTRIC
REGISTERS
DTL
PLD
COLPITTS OSCILLATOR
RUNTIME
SPICE
CHIP
PULSE
MOMENTS
POTENTIAL
MONOTONIC
DIVERGENCE

Faculty Publications

(Academic Year: 2023-2024)

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

S.No	Faculty Name	No of Journals	No of Conferences	Total
1	Dr. G. Raghotham Reddy	1	0	1
2	Smt. S.P. Girija	1	0	1
3	Dr. V. Venkateshwar Reddy	1	0	1
4	Dr. K. Sowjanya	1	0	1
5	Sri. P. Ramchandar Rao	1	0	1
	TOTAL	**5**	**0**	**5**

Publication Details

S.No.	Faculty Name	Journal Publications
1	**Dr. G. Raghotham Reddy**	Siripuri Kiran, **Ganta Raghotham Reddy**, Girija S.P., Venkatramulu S, Kumar Dorthi, Chandra Shekhar Rao V, "**A Gradient Boosted Decision Tree with Binary Spotted Hyena Optimizer for cardiovascular disease detection and classification**", in Healthcare Analytics, Volume 3, 2023, 100173, ISSN 2772-4425,
2	**Smt. S.P. Girija**	Siripuri Kiran, **Ganta Raghotham Reddy**, Girija S.P., Venkatramulu S, Kumar Dorthi, Chandra Shekhar Rao V, "**A Gradient Boosted Decision Tree with Binary Spotted Hyena Optimizer for cardiovascular disease detection and classification**", in Healthcare Analytics, Volume 3, 2023, 100173, ISSN 2772-4425,
3	**Dr. V. Venkateshwar Reddy**	**V. Venkateshwar Reddy, "**A COMPACT 1×2 MIMO ELLIPTICAL PATCH ANTENNA FOR 5G 3.5GHz APPLICATIONS," **Telecommunications and Radio Engineering**, Vol. 82, issue No. 12, pp. 21-30, 2023.
4	**Dr. K.Sowjanya**	Satish Kumar Injeti, Kotte Sowjanya, **"Investigation of Hybrid Constriction Coefcient Particle Swarm Optimization Based Butterfy Optimization Algorithm for a Minimum Transmission Power IOT Cluster with Full Connectivity",** Journal of The Institution of Engineers (India): Series B,
5	**Sri. P. Ramchandar Rao**	Thirupathi, E., Adupa, C., Rao, P.R., Gunjan, V.K., Ahmed, S.M., **"Smart Agriculture Monitoring System Using IoT"**, in Modern Approaches in IoT and Machine Learning for Cyber Security. Internet of Things. Springer, Cham. IoT

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A Gradient Boosted Decision Tree with Binary Spotted Hyena Optimizer for cardiovascular disease detection and classification

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ABSTRACT

Cardiovascular disease (CVD) is a common disorder frequently resulting in death. An increase in the death rate among adults is attributed to several factors, including smoking, high blood pressure, obesity, and cholesterol. Early diagnosis of CVDs can lower mortality rates. Algorithms that use machine learning and data mining offer the potential for finding risk variables and predicting CVD. Developing countries often need more CVD experts, and a high percentage of misdiagnosis. These concerns could be alleviated using an accurate and effective early-stage heart disease prediction system. This study explores the effectiveness of machine learning classifiers for diagnosing and detecting CVD. Several supervised machine-learning algorithms are investigated, and their performance and accuracy are compared. The Gradient Boosted Decision Tree (GBDT) with Binary Spotted Hyena Optimizer (BSHO) suggested in this work was used to rank and classify all attributes. Discrete optimization problems can be resolved using the binary form of SHO. The recommended method compresses the continuous location using a hyperbolic tangent function. The updated spotted hyena positions on the relevance score are utilized to find those with high heart disease predictions. The efficiency of the suggested model is then confirmed using the UCI dataset. The proposed GBDT-BSHO approach, with an accuracy of 97.89%, was significantly more effective than the comparative methods.

1. Introduction

The deadliest and most deadly disease affecting humans is often considered a cardiovascular disease. The high mortality rate and rising prevalence of cardiovascular [1,2] illnesses pose a severe danger to and burden on global healthcare organizations. Cardiovascular disease is more common in men than women, particularly in their forties and fifties, while children can also experience similar health difficulties [3].

Cardiovascular disease (CVD), also known as heart disease, is the leading cause of death worldwide. Cardiovascular disease is responsible for one out of every three fatalities, according to a recent World Heart Federation study [4]. According to the World Health Organization (WHO), heart failure and stroke will account for most of the 23.6 million CVD-related deaths by 2030 [5]. This type of mortality cannot be stopped, and overall death rates cannot be reduced except by preventing CVD early. Due to several risk factors, including high cholesterol, high blood pressure, smoking, diabetes, overweight, and obesity, diagnosing CVD can be challenging. There are several methods for detecting CVD that researchers have been testing. Early illness prediction is difficult because of several limitations, such as technique complexity, feature choice, and execution time [6]. The development of effective detection and prediction technologies, therefore, has the potential to save many lives.

Surgery to treat cardiac disease is challenging, particularly in underdeveloped nations with limited access to facilities, diagnostic equipment, and qualified medical personnel. Better patient care and avoiding potentially fatal heart attacks would have been possible with an accurate prediction of the likelihood of cardiac failure. Machine learning algorithms may effectively identify diseases when given the correct training data. The study shows ML-based classification techniques. So, here is a prototype early detection system for breast cancer based on machine learning. As a result, we presented six cancer disease prediction algorithms and used the confusion matrix to evaluate their performance. Other classifiers for the cancer dataset perform worse than Nave Bayes and Random Forest. This inspection uses six ML techniques to make cancer predictions based on a few characteristics [7]. Prediction systems can be assessed using publicly available datasets on

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heart disease. Researchers might create the most accurate prediction model by fusing artificial intelligence— Here are many medical uses for Artificial Intelligence (AI). Image segmentation, multidimensional imaging, and thermal imaging all benefit from improved image quality and analysis thanks to AI. It has been applied to processing signals and images, predicting functions, and controlling the urinary bladder, epileptic seizures, and strokes. AI can assist untrained doctors in developing nations in making a variety of diagnoses by using portable ultrasonic devices. - AI can also help conventional decision support systems (DSSs) enhance disease management and diagnostic accuracy to lighten staff workload.

AI has aided in diagnosing and managing tropical and cardiovascular diseases and cancer-integrated management. These applications show how AI can be an effective tool for managing and predicting conditions in an early and accurate manner and machine learning. A heart disease diagnostic approach based on machine learning (HE). Machine learning-based forecasting analytics need precise data for training and testing. If you utilize a balanced dataset for your machine-learning model's testing and training stages, you can improve its performance. Using relevant and connected data-derived features can enhance the model's predictive abilities. A robust machine learning model is necessary to get the desired outcomes. A good machine learning model is anticipated to perform well on new and old data (whereas a machine learning algorithm would otherwise only learn from the training data). The data must be standardized for the machine learning model to make more precise predictions. Recent research on adult and pediatric heart disease highlights the significance of reducing CVD-related mortality. Pre-processing is necessary since the existing clinical datasets are redundant and unreliable [8]. Choosing pertinent traits that can be used in prediction models as risk variables. The right combination of attributes and machine learning algorithms must be selected to build trustworthy prediction models.

When given the proper training data, machine learning algorithms can identify diseases. To compare various prediction models, there are readily available heart disease datasets. With machine learning and artificial intelligence, researchers can create the most accurate prediction model out of the vast databases at their disposal. Recent research on adult and pediatric heart issues has highlighted the significance of reducing deaths from cardiovascular diseases (CVDs). Current clinical data sources must be more consistent and duplicated, so pre-processing is essential. It is crucial to pick the characteristics that prediction models can use as risk factors. Correctly choosing features and algorithms for machine learning is necessary for producing a reliable predictive model. For a risk factor to be taken into account, it must meet three requirements:

- It must be highly prevalent in the majority of the population.
- It must have a sizeable independent impact on heart disease.
- It must be manageable or treatable to lower risks.

When modeling CVD predictors, various researchers have included various risk factors or characteristics. The following factors should be considered when making decisions: age, sex, chest pain (cp), elevated fasting blood sugar (FBS), exercise-induced angina (exam), ST depression caused by exercise relative to rest (old peak), slope, number of significant vessels colored by uroscopy (ca), heart status (thal), maximum heart rate achieved (thali), poor diet, and family history of CVD. According to recent research, a minimum of 14 characteristics are necessary to make the prediction accurate and reliable. To accurately predict heart disease, researchers need help combining these features with machine-learning methods. The most effective machine learning algorithms are trained on relevant datasets [9,10].

The SHO technique is recommended for use in this study by researchers and designers of meta-heuristic algorithms because it is an easy-to-use and reliable solution for complex and NP-hard problems. According to the findings, the SHO approach is quickly employed in optimization situations. In the context of an issue, optimization challenges seek optimal solutions and global points. The phases of exploration and extraction are traded off favorably by the SHO algorithm. With education and inspections, the SHO approach has advantages over other meta-heuristic methods. This increases its adaptability and broad industry use.

Machine learning techniques function effectively when taught using relevant datasets [11,12]. Because algorithms depend on the consistency of the test and training data sets, data preparation techniques like information mining, relief selection, and Least Absolute Shrinkage and Selection Operator (LASSO) can help to prepare the data. Once the pertinent characteristics have been identified, classifiers and hybrid representations can be utilized to forecast the likelihood of illness onset. Researchers employed a variety of methods to create classifiers and hybrid models. Reliable cardiac disease prediction still needs to be improved from limitations in medical datasets, feature selection, ML procedure implementation, and in-depth investigation. We intend to close some of these knowledge gaps to strengthen the CVD prediction model. The following people made contributions to the investigation:

1. Machine learning algorithms offer the potential for finding risk variables and predicting cardiovascular disease (CVD).
2. The performance and accuracy of several supervised machine-learning algorithms are analyzed.
3. The proposed Gradient Boosted Decision Tree with Binary Spotted Hyena Optimizer best predicts CVD.
4. The efficiency of the suggested model is then confirmed using the UCI dataset.
5. The proposed method compresses the continuous location using a hyperbolic tangent function.

The following sections make up this study: The literature review was summarized in Section 2. Section 3 discusses the GBDT-BSHO representation's objectives and performance evaluation. Section 4 examines future recognition summary evaluation capabilities using statistical tests and previous research. The conclusion of the proposed model and suggestions for further investigation are presented in Section 5.

2. Literature survey

When combined with Electronic Health Records, machine learning and pattern recognition are especially useful for forecasting individual outcomes from massive amounts of data (EHRs). Machine learning was used by Xi et al. [13] to increase the reliability of traditional CVD risk indicators in a sizeable UK population. Using longitudinal EHR data, machine learning algorithms were compared to a gold standard obtained by pooling cohort risk for ten-year cardiovascular event prediction.

Chen et al. [14] created a prediction method based on physical investigation markers to classify patients with hypertension. The first step is sorting through the various clinical valuation signals the patients have produced and isolating the crucial components. In the second stage, patient outcomes are predicted using the essential features discovered in the first stage. The authors subsequently suggested a model with cross-validation, recursive feature removal, and a prediction model. Extreme gradient boosting (XGBoost) aims to accurately predict patient outcomes by utilizing the best features subset.

The ensemble technique developed by Latha and Jeeva [15] was used to improve prediction accuracy. The accuracy of subpar classifiers was increased using bagging and boosting strategies, and the accomplishment of the heart disease risk identifier was deemed adequate. They aggregated classifiers from Nave Bayes, Bayes Net, C 4.5, Multilayer Perceptron, PART, and Random Forest to create the hybrid model (RF). The developed model was 85.48 percent accurate.

The UCI Heart Disease dataset was used to test machine learning methods proposed by Javid [16] and more traditional techniques like RF, Support Vector Machine (SVM), and learning models. Combining different classifiers with the voting-based model increased accuracy.

The weak classifiers showed a 2.1% improvement in the research. Other machine-learning classification methods were used in the study by NK. Kumar and Sikamani [17] to predict chronic disease. The Hoefflin classification algorithm in their research had a CVD prediction accuracy of 88.56%.

Geweid et al. [18] constructed HD identification procedures using an improved SVM-based duality optimization approach. To further comprehend the significance of our suggested method, it is helpful to consider the drawbacks and advantages of the HD diagnosis methodologies presented in the literature. All currently available methods use a variety of procedures to identify HD in its early stages. These HD prediction algorithms, however, need higher forecast accuracy and long computation times.

Amin et al. [19] A model to forecast cardiovascular disease developed by researchers by combining various variables. The datasets from the Cleveland database are accessible in the UCI machine learning repository. Each classification model—Decision Tree, Logistic Regression, Support Vector Machine, Neural Network, Vote, Naive Bayes, and k-NN—was used on different feature combinations. The statistics establish that the recommended perfect has a prediction accuracy of 87.4% for heart illness.

U. Haq et al. [20] By integrating feature selection and classification algorithms, they developed a method for recognizing HD. An algorithm for sequential reverse selecting features Both the entire feature set and a subset of it were used to assess how well the K-Nearest Neighbors (K-NN) classification model presented its results. The suggested approach produces remarkably accurate results.

Mohan et al. [21] provided a novel prediction, utilizing a comprehensive change of feature groupings and established organization techniques. The proposed hybrid random forest with a linear model (HRFLM). HRFLM uses an Artificial Neural Network (ANN) with back-propagation and 13 clinical characteristics as input. Some data mining techniques considered are DT, NN, SVM, and KNN.SVM was found to be effective in improving disease prediction accuracy. Voting, a novel approach, and a hybrid approach combining LR and NB were all put forth. 88.7% accuracy of the HRFLM method was demonstrated.

Bhuvaneswari et al. [22] With 583 Cleveland and Stat log dataset records, we achieved 95.19% accuracy. A survey result for the Rajai cardiovascular medical dataset was created with an accuracy of 79.54% using the hybrid approach. The Decision Tree Bagging approach was more than 85.03 percent accurate. To get a more precise result, three distinct datasets were pooled.

Mienye et al. [23] recommended a heart disease forecast model that uses a mean-based splitting approach to randomly divide the dataset into smaller groups in addition to classification and regression trees. Using data from the Cleveland and Framingham testing, an accuracy-based weight classifiers collaborative produced a homogeneous collaboration with organization accuracy of 93% and 91%, respectively. Saqlain and coworkers [24]. They acquired the chosen feature subset by utilizing an SVM and calculated the MCC using a validation method. The features were selected based on a Fisher score that was above average. The accuracy, sensitivity, and specificity of the MFSFSA and SVM combination were 81.19%, 72.92%, and 88.68%, respectively.

Theerthagiri et al. [25] Decision trees search for an essential element when breaking a node. In contrast, RF searches for great features among random subsets of features, which is the main difference between the two. The high variability makes the model more effective. The Bayes' theorem-based NB classifier was used to classify each pair of classified attributes independently. To discover the most probable groupings, probability theory is used. When the input is highly dimensional, this strategy is beneficial.

Dutt A et al. [26] showed that their suggested Convolutional Neural Network (CNN) architecture might predict coronary heart disease with a 77% accuracy rate. To classify clinical data that is significantly class-imbalanced, he suggests an effective neural network with convolutional layers. To forecast the development of Coronary Heart Disease, data from the National Health and Nutritional Examination Survey (NHANES) have been carefully selected (CHD). Contrary to the massive percentage of the existing machine learning models used on this data type, our straightforward two-layer CNN demonstrates resilience to the imbalance with reasonable harmony in class-specific performance. In contrast, these models remain susceptible to class imbalance even after adjusting class-specific weights.

Gao et al. [27] created a cardiac disease prediction model that incorporates collaborative methods (boosting and bagging) and feature extraction procedures. This model aims to enhance accuracy (LDA and PCA). The researchers analyzed how five different classifiers performed on a subset of Cleveland heart disease features. In addition to DT, these classifiers comprised SVM, KNN, RF, and NB. Bagging and boosting are two different types of ensemble approaches. The consequences of the experiments established that the best results were obtained using the bagging collaborative learning technique along with DT and PCA feature extraction. Increasing came in second place.

Ali et al. [28] suggested stacking two support vector machines (SVMs) to improve the accuracy of a CVD presence prediction and achieve better results. When using a hybrid grid search approach to tune a model, The first SVM removed extra features, and the second SVM detected CVD. Both SVMs were used in the same modeling project.

Saqlain et al. [29] The Mean Fisher score feature selection algorithm (MFSFSA) and the SVM organization were used to develop the methodology. A feature's quality is established if its Fisher score exceeds the average. The MCC was then trained and calculated using a Support Vector Machine (SVM) validation technique using the provided subset of attributes. According to the study's findings, combining FSFSA with SVM can result in accuracy levels as high as 81.19 percent, sensitivity levels as high as 72.92 percent, and specificity levels as high as 88.68 percent.

Asher et al. [30] These learning algorithms used Nave Bayes, multilayer perceptrons, Bayes Net, J48, KNN, random trees, and random forests, among other algorithms. Also employed were ensemble prediction techniques. The highest precision rate (70.77%) was recorded for J48. With the aid of cutting-edge technologies, KERAS' accuracy was raised to 80%. An evaluation multi-task (MT) recurrent neural network will be created to predict when a cardiovascular disease will start to manifest. The AUC rises by 2 to 6% when using the suggested model.

Takci [31]. Twelve classification algorithms and four different feature selection techniques were applied to predict cardiac crises. The models were assessed using their accuracy, processing speed, and ROC analysis outcomes. The accuracy rate with feature extraction was 84.81 percent, compared to the maximum accuracy of 82.59 percent without it. Using naive Bayes and linear SVM, a model with an accuracy of 84.81% was discovered. The processing time was cut in half, from 359 to 187 ms. Giving to the unkind accuracy assessment, the Relief approach produces the highest model accuracy out of the four potential feature selection approaches. When feature point combinations are considered, the author claims that the choice of features favors heart attack results, whether actual or potential.

Ashok Kumar Dwivedi [32]. Using tenfold cross-validation, this study will inspect the efficacy of many machine-learning procedures in predicting cardiac disease. Naive Bayes, Classification Tree, KNN, Logistic Regression, Support Vector Machines (SVM), and Artificial Neural Networks were some of the methods used in the study (ANN). In that order, the results were 83%, 77%, 80%, 85%, 82%, and 84%. In terms of precision, Logistic Regression outperforms other techniques.

Ankur. [33] heart disease can be misdiagnosed using traditional medical history. Non-invasive classification of healthy and heart disease patients is possible with machine learning. Using datasets. Seven well-known machine learning algorithms, three feature selection algorithms, cross-validation, and performance metrics for classifiers like classification accuracy, specificity, sensitivity, Matthews' correlation coefficient, and execution time were all used. Heart disease patients can be easily identified using the suggested system. Each classifier's detector

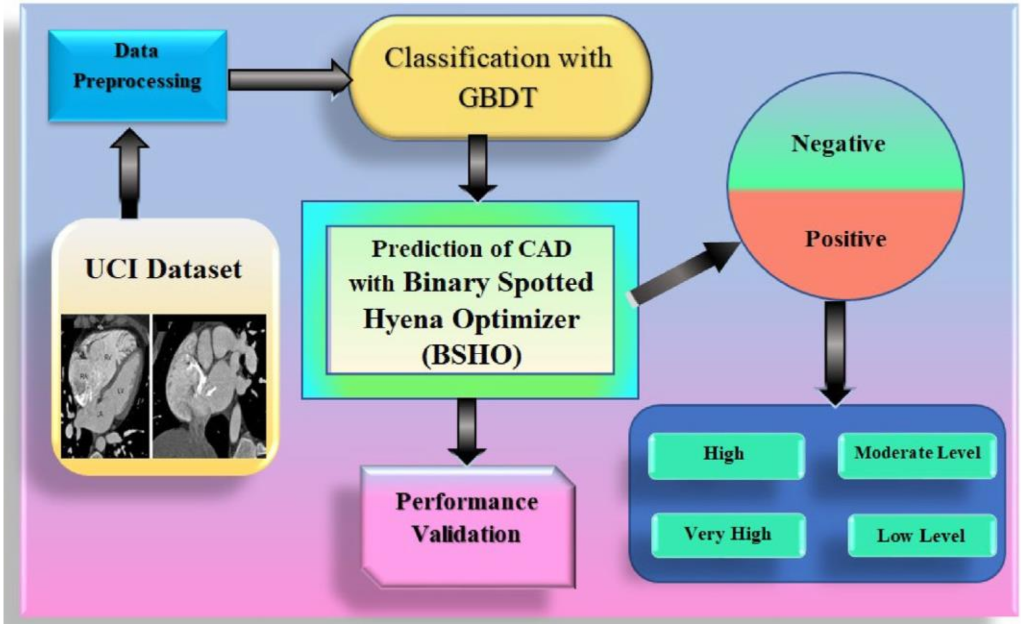

Fig. 1. Proposed model of GBDT-BSHO.

optimism curves and area under the curves were calculated. Feature reduction affects the classifier's precision and speed. The machine learning-based decision support system allows physicians to diagnose heart patients more quickly.

Amin [34] uses the AI architectural style machine intelligence structure to diagnose heart disease (MIFH). The MIFH framework can predict both healthy and unhealthy subjects. To train machine learning forecasting analytics that classifies heart disease and healthy subjects, MIFH uses Factor Analysis of Mixed Data (FAMD) to extract and deduce features from the UCI Cleveland heart disease set of data. The MIFH algorithm uses the weight matrix of performance measures to select the best classifier.

3. Proposed system

3.1. Pre-processing of data

Many automated diagnostic techniques have been recently established for diagnosing many ailments, including social heart illness. Numerous datasets have been successfully used for automatic heart disease identification utilizing machine learning algorithms and optimization, and their significance in medical science is now widely recognized. Various machine learning approaches are employed to categorize or forecast the results and diagnose the ailment. ML algorithms are capable of quickly analyzing large amounts of genetic data. Estimates may be improved by using and analyzing medical data in greater depth and training pandemic prediction algorithms [35]. The dataset provides various insights that aid in our comprehension of the significance of each variable and its interrelationships. This study aims to identify people with severe heart conditions [36]. Fig. 1 represents the architectural layout of the projected perfect.

The graphic clearly shows that the UCI dataset has proceeded to the preprocessing step, defined as any processing done on raw data to prepare it for further data processing activities. It has historically been an essential first step in data mining.

The preprocessed data is classified using gradient-boosted decision trees, a well-liked method for dealing with prediction issues in both the regression and classification domains. The technique progresses learning by streamlining the objective and lowering the number of repeats necessary for an appropriately optimal explanation. The result is predicted using BSHO, where the effect can be positive or negative. If the result is tested positive, it is further checked for its severity level, ranging from very low to very high. The data is validated to prove its performance is better than the other technique.

3.2. Decision tree with gradient boosting (GBDT)

Machine learning techniques for classification and regression include gradient boosting. It makes predictions using decision trees, the weakest estimation technique most frequently used. It combines several smaller, more inefficient models into one robust model that is very good at forecasting. This kind of model is so well-liked because it is efficient at quickly classifying datasets. Models for gradient-boosting classifiers are frequently developed using decision trees. The three main features of angle boosting are:

- Loss function optimization.
- Teaching a weak learner to make accurate predictions.
- Modifying vulnerable learners to an optimization strategy to reduce the loss function.

The loss function must be distinct and appropriate for the problem under consideration. Gradient Boosting views Decision Trees as the weak learner. Regression trees can be used to incorporate subsequent predictive modeling and correct residuals in predictions because their outputs can be added up, and they generate fundamental values as random outcomes. Trees are built based on Gini's purity ratings to minimize loss or choose the best-split score. An additive model keeps the previous trees in place while displaying trees one at a time. The gradient descent method can reduce the likelihood of error when adding trees.

1. Loss Function

The type of loss function to be used depends on the solution domain. Despite the availability of numerous widely used loss functions and the possibility of developing your own, it must be unique. In regression, for instance, you might use a squared error, and in classification, a logarithmic loss. Gradient boosting has the advantage that only one growing algorithm is needed for all differentiable loss functions. Instead, any variational loss function may be used because of the straightforward method.

2. Weak Learner

Algorithms based on decision trees were frequently used as a slow learning technique for gradient boosting. Because they provide better-split values and can be connected, regression trees were added. This enables the addition of new model outputs and the "correction" of prediction residuals. The finest split tips are chosen based on their purity scores to minimize loss. Initially, programs like AdaBoost used "decision stumps", which are very short decision trees with just one break. Sometimes weak learners are only allowed access to a certain amount of layers, nodes, leaves, or root nodes.

3. Additive Model

The model's current trees are left alone; new trees are instead gradually added. The impact of adding trees is lessened when using a gradient descent approach. Neural networks frequently employ the technique of gradient descent to explain several variables, such as regressors or weights. The weights are changed to produce a better fit after resolving the error or loss issue. Decision trees, or more precisely, poor learner submodels, take the place of rules. We can estimate the loss before applying the gradient descent approach and then include a tree in the model to lessen the loss.

Establishing non-linear decision boundaries is made simple by GBDT's hierarchical nature. The learner base of the GBDT learning process is most strongly correlated with the negative gradient of the loss objective in practical applications. The GBDT perfect converges globally by removing the negative angle, in contrast to conventional boosting techniques that employ weighted samples for both the positive and negative. Loss function minimization via weak learner addition, loss function optimization, and weak learner predictions make up gradient boosting (additive model). The nature of the problem affects the loss function. Logarithmic loss and mean squared error (MSE) are commonly used in regression and classification issues. Optimizing just the unexplained loss from previous iterations is preferable instead of starting the boosting procedure from scratch at each level. Decision trees are also used as weak learners to construct an additive model for loss function minimization that includes vulnerable learners. The trees are then combined into one file through concatenation. The existing model trees are not altered. The gradient descent approach can minimize the loss that occurs when adding trees. Additionally, $\{y_j, z_j\}_{j=1}^{n}$ displayed the dataset, and SoftMax was used as the loss function. Gradient descent was used to guarantee the model's convergence. The traditional Softmax loss function comprises the Softmax and cross-entropy loss functions. Image classification extensively uses it due to its quick learning and high performance. However, the Softmax loss function employs an inter-class competition mechanism, is only concerned with the correct label's prediction probability precision, ignores the distinction between proper and incorrect labels, and cannot guarantee intra-class compactness or inter-class discreteness. L-Softamax augments Softmax's foundation with an angle constraint to emphasize class differences. The recognition standard requires a minimum intra-class distance. A-Softmax improves Softamx by using normalized weights and angular spacing. In this model, M stands for the extreme amount of training iterations, and ϖ the learning rate determines the step size for updates that mix the weights of different trees to prevent over-fitting. The minor loss reduction necessary for a subsequent division on a leaf node is likewise indicated by the letter μ_d. The GBDT model operates as shown below.

Step 1 :The model's constant μ's starting value is given

$$g_0(y) = \arg\min_{\mu} \sum_{j=1}^{N} L(z_j, \mu) \tag{1}$$

Step 2 : d = 1 to D specifies the number of iterations

Step 2.1 When combining the weights of various trees, Eq can be used to determine the lowest loss reduction and the step size (2).

$$\left(\mu_d, \varpi_d\right) = \arg\min_{\mu,\varpi} \sum_{j=1}^{N} L\left(z_j, g_{d-1}\left(y_{k,j}\right) + \varpi b\left(y_{k,j}; \mu\right)\right) + vT + \frac{1}{2}\alpha\|\mu\|^2 \tag{2}$$

Step 2.2 As follows, the model is updated.

where T represents all of the leaves on the tree. It should be emphasized that model fitness is calculated using training data by the loss function L, while model complexity is resolute by the term $\varpi b\left(y_{k,j}; \mu\right)$. The complexity of the model is penalized by the term $vT + \frac{1}{2}\alpha\|\mu\|^2$ as well.

$$G_d(y) = G_{d-1}(y) + \varpi_d b(x_{k,j}; \mu_m) \tag{3}$$

Step 3 $G_d(y)$ is returned after applying D additive functions to the output.

$$\hat{z}_{GBDT} = \sum_{j=1}^{D} \varpi_m b(y; \mu_m) \tag{4}$$

Given a sample Z, GBDT generates the output using D additive functions, as illustrated in the following equation.

A GBDT model can forecast the pseudo-residuals of the previous trees given any differentiable loss function because it computes a succession of trees. The user defines the process that determines the accompanying negative gradient and the arbitrary loss function. In fact, by combining predictions and training each new model, the loss function is minimized. A gradient boosting model's tree count is essential because too many trees can lead to over-fitting, and too few can lead to under-fitting.

3.3. Binary Spotted Hyena Optimizer (BSHO)

On this broadside, a hyena optimizer with binary markings is depicted (BSHO). Spotted hyenas' discrete binary search space-hunting strategy served as the model for this strategy. It imitates spotted hyenas' hunting strategies. The spotted hyena establishes a social network of dependable people by hunting in groups. They track down their target, encircle it, and then start their attack. Search agents are only allowed to move to the corners of the search space, which is how the binary spotted hyena optimizer sees it. Since each response may be either 0 or 1, they are all binary. Based on the location of the person who is best positioned, the remaining spotted hyenas move into position. The part of the spotted hyena is modified using the provided hyperbolic tangent function. Between "0" and "1" are the factors that have changed due to the suggested tangent function.

3.3.1. Spotted hyena optimizer

The recently created spotted hyena optimizer (SHO), a new optimization method, is based on the spotted hyena's hunting tactics. The social, spot-covered hyenas forage and huddle together in packs both day and night. The main behaviors incorporated in this algorithm are searching for prey, surrounding prey, and attacking game, in addition to other searching behaviors displayed by spotted hyenas. The aimed-for target or objective close to the optimum during this process is the most promising candidate solution because the search space is unknown in advance. Other participants in the SHO make an effort to update their positions by forming a cluster of reliable friends in the direction of the elite search agent, presuming that the latter is aware of the location of the prey. SHO has three main elements: encircling, hunting, and attacking prey. Right now, prey is the best option. It is almost flawless. After determining the optimum solution, the surviving spotted hyenas attempt to modify their places. The following equations can be used to represent the spotted hyena's encircling behavior quantitatively:

$$\vec{R}(p+1) = \vec{R}_r(p) - \vec{T}.\vec{B}_h \tag{5}$$

where $\vec{B}_h$ indicates how far away the hyena is from the intended victim. $\vec{U}$ and $\vec{T}$ are the coefficient vectors. P stands for the most recent edition. The spotted hyena's position vector is denoted by $\vec{R}$, whereas the location vector of its prey is denoted by $\vec{R}_r$. The following formula is used to compute $\vec{U}$ and $\vec{T}$ values:

$$\vec{U} = 2.\vec{rand}_1 \tag{6}$$

$$\vec{T} = 2\vec{h}.\overrightarrow{rand_2} - \vec{h} \quad (7)$$

$$\vec{h} = 5 - (Iteration \times (5/Max_{Iteration})) \quad (8)$$

where $Iteration = 1, 2, 3, \ldots, Max_{Iteration}$
$\vec{h}$ decreases linearly during the duration of the iterations, from 5 to 0. It is used to preserve a stability between exploration and extraction. The random vectors in [0,1] are $\overrightarrow{rand_1}$ and $\overrightarrow{rand_2}$ The Max $_{iteration}$ limitation indicates the maximum amount of iterations. To recover efficiency, the number of iterations must be high. So that spotted hyenas can travel to other regions close to their current location, $\vec{U}$ and $\vec{T}$'s specifications are changed. Using Eqs, spotted hyenas can randomly shift where they are about their prey. (5) and (6)

Hunting: Hyenas typically hunt, live in packs, and have excellent prey location skills. It is assumed that the best search factor is an optimal factor that is aware of the location of the prey to represent the behavior of hyenas mathematically. Other search agents update the top outcomes they have found as they collaborate to find the best search agent.

$$\vec{B}_h = |\vec{U}.\vec{R}_h - \vec{R}_k| \quad (9)$$

$$\vec{R}_k = \vec{R}_h - \vec{T}.\vec{B}_h \quad (10)$$

$$\vec{M}_h = \vec{R}_k + \vec{R}_{k+1} + \cdots + \vec{R}_{k+N} \quad (11)$$

where R_h stands for the finest spotted hyena's position and R_k is the location of all other spotted hyenas. The formula for calculating N, the number of spotted hyenas, is as surveys:

$$N = count_{NP}\left(\vec{R}_h, \vec{R}_{h+1}, \vec{R}_{h+2}, \ldots \left(\vec{R}_h + \vec{C}\right)\right) \quad (12)$$

where [0.5, 1] is the range for the random vector $\vec{C}$'s value. NS denotes the number of aspirant explanations closest to within the defined search space, the best optimal description. The best cluster for N is $\vec{C}$h. This image displays the mathematical strategy used to attack the prey.

$$\vec{R}(p+1) = \frac{\vec{M}_h}{N} \quad (13)$$

By storing the best solution in $\vec{R}(p+1)$ and ordering other search agents to move into positions based on the location of the most excellent search representative. SHO allows its hyenas to change their sites and their prey's locations.

The problems of continual optimization contributed to creating the first spotted hyena optimizer (SHO). However, it cannot be used to address specific issues directly. SHO's binary version can fix this problem (BSHO). The binary encoding scheme BSHO converts SHO's float-encoding technique into a system where each variable can only have a 0 or 1. The spotted hyena position update approach is suggested to strengthen local search abilities and discover improved solutions in the binary search space. The hyperbolic tangent function is the most effective method for updating the whereabouts of spotted hyenas. To resolve discrete optimization issues, SHO has a binary version. As a result, the hyperbolic tangent function is used to discretize the continuous positions. According to experimental findings, the updated version is a valuable technique for feature selection and test functions. Also, the outcomes are superior to or comparable to competing metaheuristic methods.

Hyperbolic functions have analogs, just like circular and trigonometric functions. The hyperbolic function is used to solve cartesian coordinates, Laplace's equations, hyperbolic geometry, and linear differential equations. The hyperbolic procedure is typically performed at the hyperbolic angle. As activation functions in neural networks, hyperbolic tangent functions can replace sigmoid functions. Backpropagate uses the derivative of the activation function to calculate the effects of errors on weights. The result of the hyperbolic tangent function is straightforward, just like the sigmoid function. Only numbers between "0" and "1" impact the placements in BSHO.

Consequently, the search space dimension extends from 0 to 1.
BSHO sets itself apart from other binary metaheuristics by using a clustering method. Here is an illustration of a mathematical cluster creation model.

$$M_h = R_k + R_{k+1} + \cdots + R_{k+N} \quad (14)$$

where M_h stands for the group of ideal solutions produced by the suggested algorithm.

$$x_d^{x+1} = \begin{cases} 1, & Z(M_h) \geq rand \\ 0, & Otherwise \end{cases} \quad (15)$$

$$Z(M_h) = \tanh(M_h) = (\exp^{-\delta(C_h)} - 1)/(\exp^{-\delta(C_h)} + 1) \quad (16)$$

A rand is a random number from the [0, 1] range. The binary position, x^{x+1} dimension, iteration number, and δ the spotted hyena values are ^{d}in d, s, and 1, respectively.

Binary Spotted Hyena Optimizer Algorithm (BSHO)

Input: Number of Spotted hyenas, R_i (i = 1,2,. .... ,n)
Output: Best Spotted Hyena

1. Initialize population of n hyenas randomly
2. Calculate the fitness value of each search agent.
3. While(p < Max number of iterations)
4. for each spotted hyena
5. update the position of the search agent according to Eq. (16)
6. end for
7. Update control parameters **U, T, h** and **N**
8. Compute the fitness value of each spotted hyena
9. Update $R_h$if it is better than the previous solution
10. Update the cluster M_h w.r.t R_h
11. p = p + 1
12. end while

Fig. 2 depicts a classification of SHO approaches considering hybridization, improvement, BSHO variations, and optimization issues. The three subcategories of hybridization are supporting vector regression, artificial neural networks (ANNs), and support vector analysis (SVR). Utilizing various subcategories, the solutions found in the upgraded category are improved. Some subcategories are binary and multi-objective that fall under BSHO. In conclusion, the BSHO is used to solve different optimization problems and find the best solution using optimization problems.

4. Result and discussion

4.1. Experimental setup

The datasets examined are from the 303 entries and 76 attributes of the Academy of California, Irvine (UCI) machine learning group. Due to missing values in the data, pre-processing was necessary, subsequent in an example of 302 registers with just 14 heart disease characteristics. Using a significant amount of data on heart disease from various sources, the projected method is contrasted beside 12 different ML classifiers in terms of accuracy, precision, recall, F1 score, and RMSE standards.

4.2. Performance metrics

When the proposed ML model must be assessed using both expected and actual results, precision is a suitable evaluation criterion [37,38]. It determines the ratio of real positives to anticipated positives. It thus heavily depends on TP and FP levels when calculating the number of positives that can be accurately projected.

$$Precision = \frac{TP}{TP + FP} \quad (17)$$

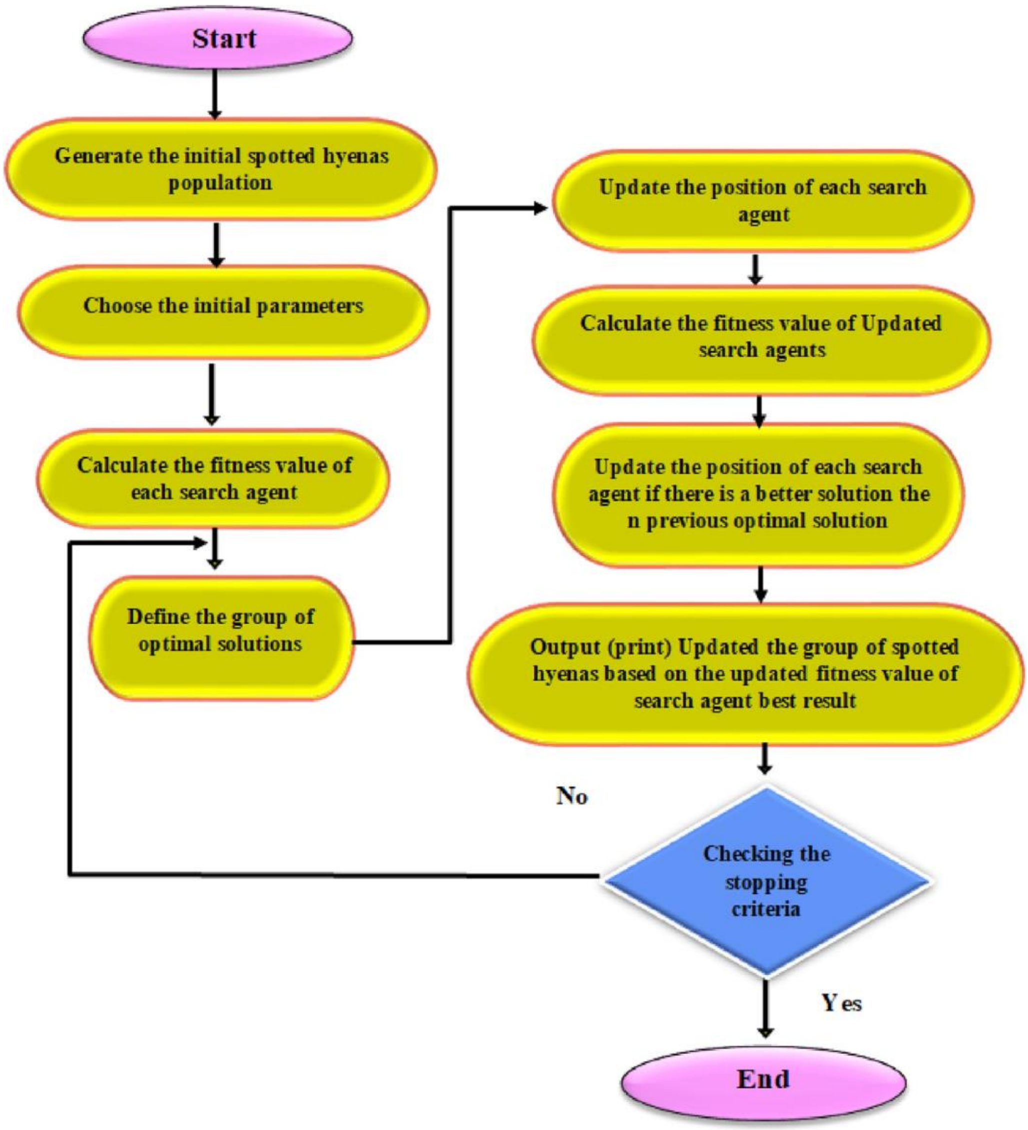

Fig. 2. BSHO flowchart.

Another relevant evaluation parameter [39,40] recalls, representing the fraction of correctly classified positives. The TP and FP values are used to calculate memory.

$$Re\,call = \frac{TP}{TP + FN} \tag{18}$$

The F-Score represents a classifier's trade-off between recall and precision. A measure's F-score, which ranges from 0 to 1, describes how statistically accurate and trustworthy it is.

$$F - Score = 2 * \frac{precision * recall}{precision + recall} \tag{19}$$

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \tag{20}$$

1. Precision

Fig. 3 and Table 1 provide a precision comparison of the GBDT-BSHO methodology with numerous other known procedures. The graph depicts how the machine learning method improved performance and precision. The GBDT-BSHO model, for example, has a precision of 93.64% for data set 100, whereas the SVM, Decision Tree, KNN, Logistic Regression, and MLP models have precisions of 74.32%, 78.94%, 82.94%, 85.24%, and 90.75%, respectively. However, the GBDT-BSHO model performed best with various data set sizes. Similarly, the precision value of GBDT-BSHO under 600 data points is 97.86%, 79.35%, 82.98%, 87.97%, 90.27%, and 94.74% for SVM, Decision Tree, KNN, Logistic Regression, and MLP models, respectively.

Table 1
Analysis of GBDT-BSHO precision using the current system.

No of data from dataset	SVM	Decision Tree	KNN	Logistic Regression	MLP	GBDT-BSHO
100	74.32	78.94	82.94	85.24	90.75	93.64
200	75.93	80.27	84.39	85.89	91.64	95.21
300	77.24	79.47	85.26	86.32	93.89	95.99
400	76.85	81.05	87.34	88.27	94.02	96.29
500	77.90	82.54	86.85	88.73	94.21	97.13
600	79.35	82.98	87.97	90.27	94.74	97.86

2. Recall

A recall comparison of the GBDT-BSHO methodology with other methods available is shown in Fig. 4 and Table 2. The graph depicts how the machine learning method improved performance and recall. For data set 100, the GBDT-BSHO model has a recall value of 92.09%, whereas the SVM, Decision Tree, KNN, Logistic Regression, and MLP models have recall values of 61.08%, 67.37%, 76.39%, 83.25%, and

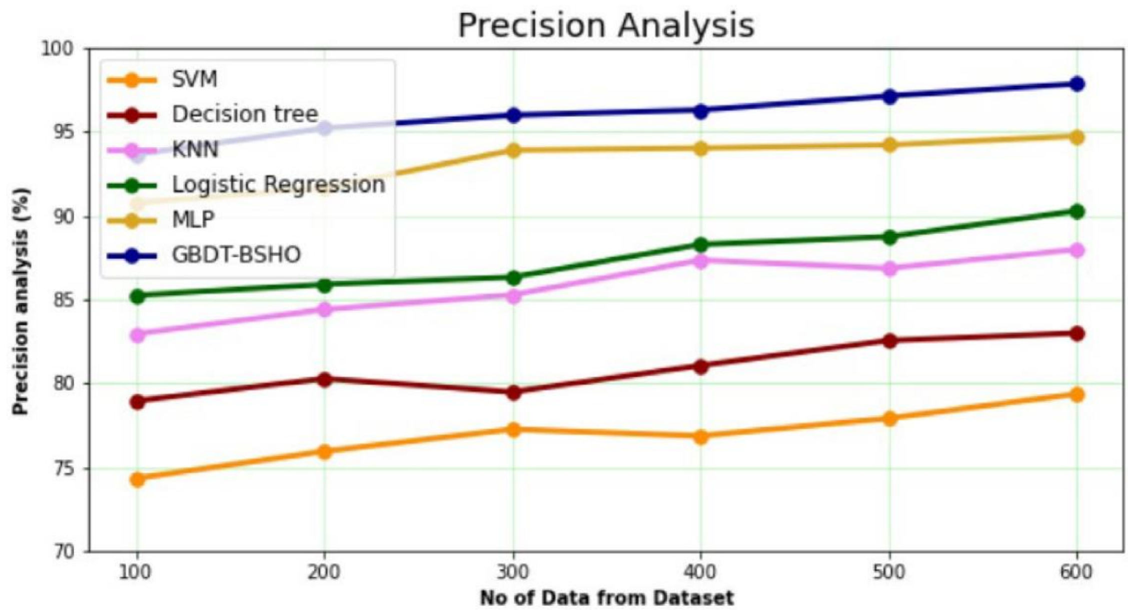

Fig. 3. GBDT-BSHO precision analysis with existing system.

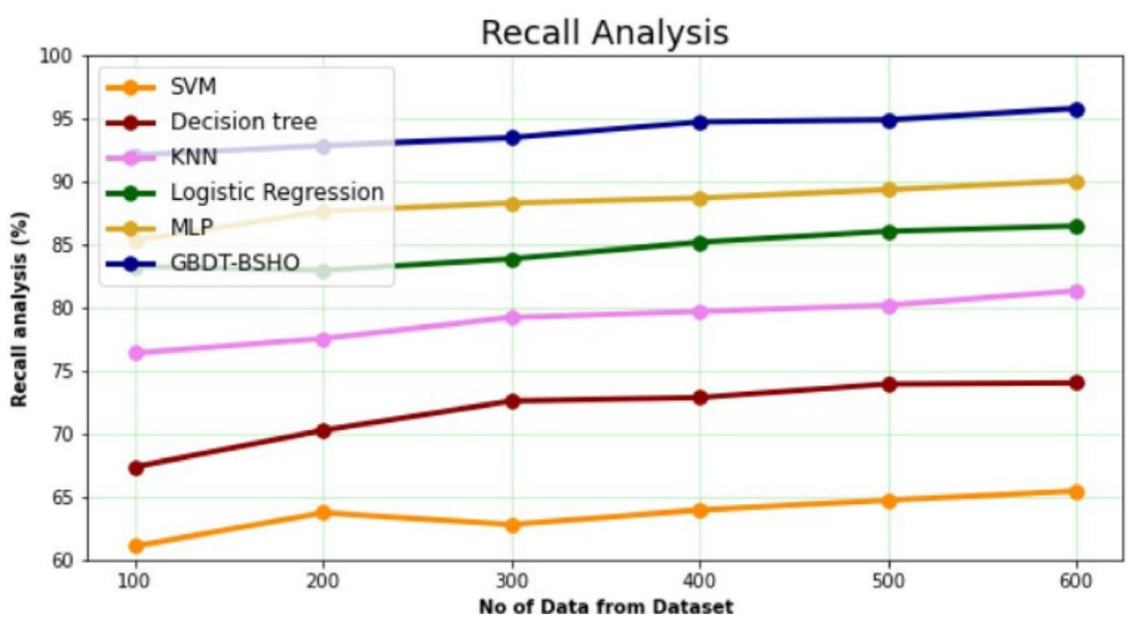

Fig. 4. GBDT-BSHO recall analysis using the existing system.

Table 2
Recall analysis for GBDT-BSHO using existing system.

No of data from dataset	SVM	Decision Tree	KNN	Logistic Regression	MLP	GBDT-BSHO
100	61.08	67.37	76.39	83.25	85.32	92.09
200	63.73	70.26	77.54	82.94	87.63	92.84
300	62.80	72.58	79.22	83.86	88.29	93.46
400	63.94	72.86	79.68	85.17	88.70	94.72
500	64.72	73.94	80.19	86.05	89.34	94.89
600	65.46	74.05	81.32	86.48	90.05	95.78

85.32%, respectively. On the other hand, the GBDT-BSHO model performed best with various data set sizes. Similarly, GBDT-BSHO has a recall value of 95.78% for 600 data points, compared to recall discounts of 65.46%, 74.05%, 81.32%, 86.48%, and 90.05% for SVM, Decision Tree, KNN, Logistic Regression, and MLP.

3. F-Score

In Fig. 5 and Table 3, the GBDT-BSHO strategy is compared to other known methodologies using f-scores. According to the graph, the machine learning approach improved f-score performance. The GBDT-BSHO model, for example, has an f-score of 93.275% for data set 100, while the SVM, Decision Tree, KNN, Logistic Regression, and MLP models have f-scores of 72.578%, 79.483%, 84.872%, 86.382%, and 90.210%, respectively. The GBDT-BSHO model, however, excelled with different-sized data sets. The f-score for the GBDT-BSHO model under 600 data points is 97.438 percent, compared to 77.143%, 83.184%, 87.964%, 90.643%, and 93.673% for the SVM, Decision Tree, KNN, Logistic Regression, and MLP models, respectively.

4. Accuracy

The accuracy of the GBDT-BSHO method is evaluated by comparing it to other currently employed techniques in Fig. 6 and Table 4. The

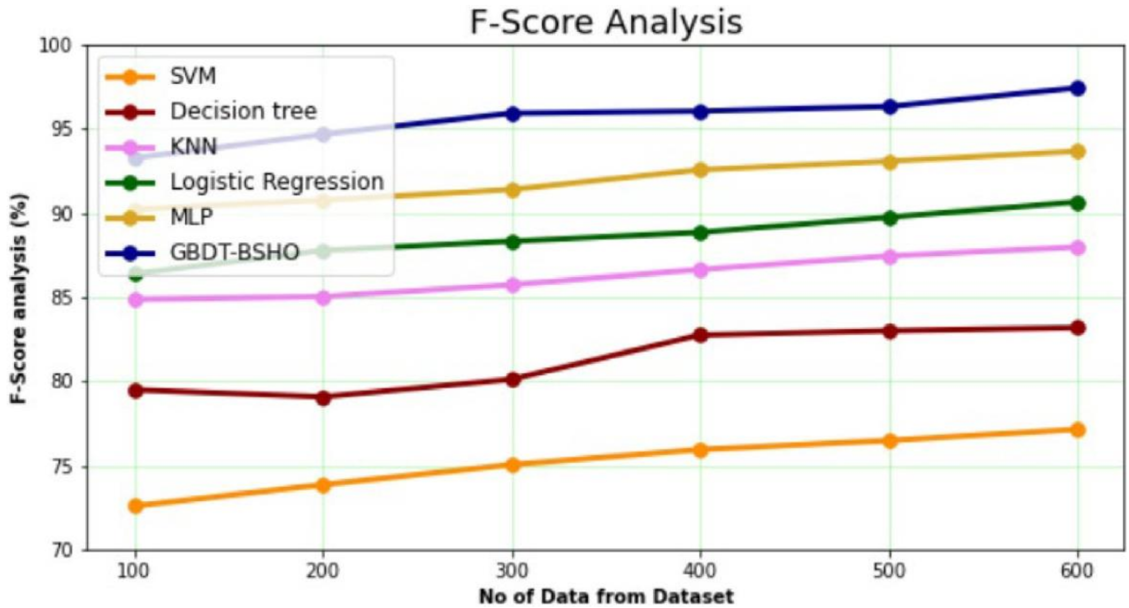

Fig. 5. GBDT-BSHO F-Score analysis with existing system.

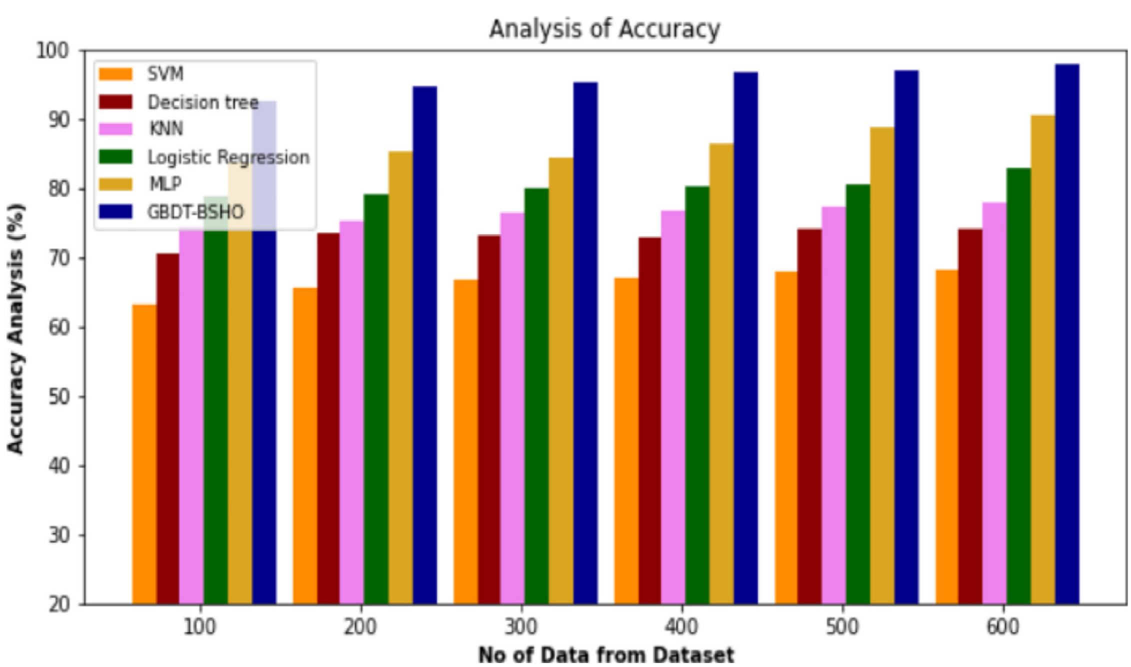

Fig. 6. Analysis of GBDT-BSHO accuracy using existing system.

Table 3
Analysis of GBDT-BSHO F-scores using an existing system.

No of data from dataset	SVM	Decision Tree	KNN	Logistic Regression	MLP	GBDT-BSHO
100	72.578	79.483	84.872	86.382	90.210	93.275
200	73.842	79.065	85.034	87.764	90.758	94.674
300	75.034	80.108	85.735	88.319	91.390	95.927
400	75.938	82.739	86.632	88.847	92.567	96.054
500	76.475	82.989	87.437	89.749	93.074	96.325
600	77.143	83.184	87.964	90.643	93.673	97.438

Table 4
Analysis of GBDT-BSHO accuracy using an existing system.

No of data from dataset	SVM	Decision Tree	KNN	Logistic Regression	MLP	GBDT-BSHO
100	63.09	70.58	74.38	78.74	83.78	92.78
200	65.43	73.49	75.29	79.01	85.39	94.83
300	66.87	73.18	76.39	79.85	84.52	95.39
400	67.04	72.85	76.84	80.34	86.40	96.64
500	67.93	73.98	77.21	80.56	88.76	97.05
600	68.24	74.09	77.87	82.97	90.72	97.89

graph depicts how machine learning improves performance and accuracy. Given data set 100, the GBDT-BSHO model's accuracy is 92.78%, while the SVM, Decision Tree, KNN, Logistic Regression, and MLP models' accuracy is 63.09%, 70.58%, 74.38%, 78.74%, and 83.78%, respectively. The GBDT-BSHO model, however, excelled with various data set sizes. SVM, Decision Tree, KNN, Logistic Regression, and MLP

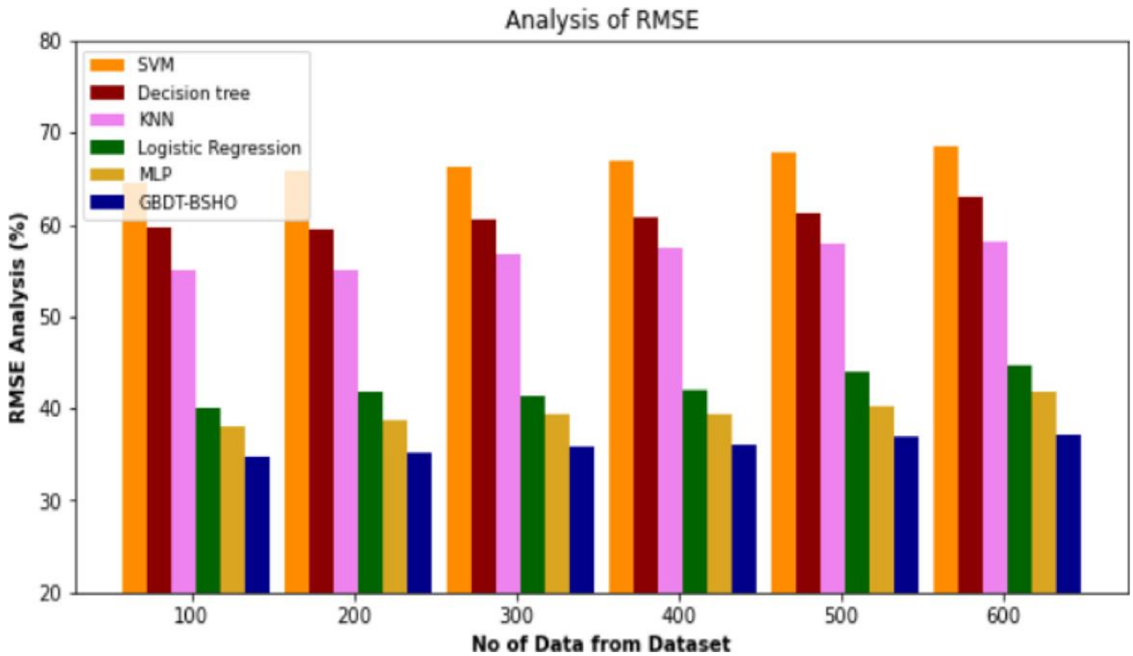

Fig. 7. GBDT-BSHO RMSE analysis with existing system.

Table 5
RMSE analysis with existing system using GBDT-BSHO.

No of data from dataset	SVM	Decision Tree	KNN	Logistic Regression	MLP	GBDT-BSHO
100	64.571	59.744	54.980	40.053	38.098	34.754
200	65.873	59.376	55.078	41.752	38.693	35.276
300	66.241	60.538	56.849	41.265	39.289	35.783
400	66.975	60.849	57.424	42.054	39.477	36.092
500	67.903	61.274	57.857	43.958	40.235	36.862
600	68.453	63.078	58.175	44.754	41.836	37.176

models have accuracy values of 68.24%, 74.09%, 77.87%, 82.97%, and 90.72%, respectively, while GBDT-BSHO has a similar accuracy under 600 data points of 97.89%.

5. RMSE

Fig. 7 and Table 5 display the RMSE comparison of the GBDT-BSHO comprehensive strategy with other well-known methods. Based on the graph. With a lower RMSE value, the algorithm for machine learning produced better results. Concerning data set 100, for instance, the RMSE for the GBDT-BSHO model is 34.754%, whereas the RMSE values for the SVM, Decision Tree, KNN, Logistic Regression, and MLP models are 64.571%, 59.744%, 54.980%, 40.053%, and 38.098%, respectively. For various data sizes, the GBDT-BSHO model, on the other hand, has demonstrated maximum performance with low RMSE values. Similarly, the RMSE value of GBDT-BSHO under 600 data points is 37.176%, while SVM, Decision Tree, KNN, Logistic Regression, and MLP models have RMSE discounts of 68.453%, 63.078%, 58.175%, 44.754%, and 41.836%, respectively.

5. Conclusion

The possibility of contracting heart disease can significantly affect how long a person lives, regardless of their social or cultural background. Early detection is the first step in achieving that goal. Predicting cardiac disease using machine learning has been the subject of numerous studies. In this study, similar procedures are followed, but the strategy is better and novel, and the dataset used to train the model is more extensive. The findings of this study show that the Relief method for choosing features may result in a feature set that is highly correlated and can be used with other machine learning algorithms. Researchers and medical experts must focus on CVDs because they are severe medical problems. This study aims to find the machine learning classification framework with the highest diagnostic precision. To predict cardiac disease, several supervised machine-learning techniques were employed and contrasted. Based on a Gradient Boosted Decision Tree, this study recommends a Binary Spotted Hyena Optimizer (BSHO) for ranking and categorizing all qualities (GBDT). Discrete optimization issues can be handled with the binary form of SHO. The suggested technique compresses the continuous position using the hyperbolic tangent function, then updates the location of spotted hyenas using the values produced to determine those with a high prognosis accuracy for heart illness based on the importance score. Finally, the suggested model's effectiveness is validated using the UCI dataset. The GBDT-BSHO approach and established machine learning categorization assessed both the presence and absence of cardiovascular disease, with a model summary accuracy of 97.89%, an average sensitivity (or recall) of 97.89%, an average precision of 97.86%, and an average model and F1-score of 97.43%. The model will be further standardized in subsequent research to be applied with various methods for selecting features and datasets that contain a significant amount of missing data. This study aimed to advance prior work by developing a novel and new model that would be useful and simple to apply in practical settings.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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A COMPACT 1 × 2 MIMO ELLIPTICAL PATCH ANTENNA FOR 5G 3.5 GHz APPLICATIONS

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For 5G 3.5 GHz applications, a compact 1x2 multiple inputs and multiple outputs (MIMO) elliptical patch antenna is proposed. An antenna that has dimensions of 21.5 × 43 × 1.6 mm³ with MIMO is constructed on a FR4 substrate with 4.4 relative permittivity. Rectangular cuts are employed on an elliptical patch, and antenna elements are arranged orthogonally to achieve a better isolation of –20.08 dB at the resonant frequency of 3.5 GHz. A 3.29–3.8 GHz bandwidth is produced below –10 dB through ground plane construction. The proposed antenna gain is 2.36 dB. The MIMO features are calculated with good results, including ECC < 0.003, DG > 9.9998, TARC < –10 dB, CCL < 0.3, and MEG.

KEY WORDS: *envelope correlation co-efficient, diversity gain, total active reflection coefficient, channel capacity loss, mean effective gain*

1. INTRODUCTION

Current 5G wireless communication systems demand small, wide-band MIMO antennas with improved port isolation. With its high efficiency, low latency, maximum throughput, and improved channel capacity, the MIMO antenna is essential for extending the transmission range without raising the signal power (Kumar et al., 2020). ITU-R standards divide the 5G spectrum into two frequency ranges: frequency range 1 (FR1) and frequency range 2 (FR2). FR1 (Anitha et al., 2016; Irfansyah et al., 2021) offers 410 MHz to 7125 MHz at frequencies below 6 GHz, and FR2 is above 6 GHz and offers 24.25 GHz to 52.6 GHz.

A circular patch is used for sub-6 GHz applications. Elements are placed in the same direction, and isolation is obtained –15 dB below (Desai et al., 2020). An elliptical patch crescent shape MIMO antenna is proposed for sub-6 GHz applications. Here, antenna elements are arranged orthogonally, but the antenna size is greater when compared to the proposed antenna (Sree et al., 2022). The elliptical patch antenna is proposed for 5G c-band applications, and here, the probe feed is applied (Mishra et al., 2019). A circular patch antenna is proposed for sub-6 GHz applications, and this antenna is operated in dual bands from 3.64–3.81 GHz and 4.27–4.43 GHz. Here, antenna elements are arranged in the same direction so isolation achieved for this antenna is –15.27 dB below and has a large size (Gomase et al., 2019). A rectangular patch antenna with two array

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ORIGINAL CONTRIBUTION

Investigation of Hybrid Constriction Coefficient Particle Swarm Optimization-Based Butterfly Optimization Algorithm for a Minimum Transmission Power IOT Cluster with Full Connectivity

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Abstract In this new age of the Internet of Things (IoT), maintaining a link between sensor nodes that is both reliable and efficient in its use of energy is of the utmost significance. Engineers working in wireless technology frequently face a trade-off between the energy requirements of sensors and the reliability of their complete connectivity. As a result of this necessity, a large number of researchers are focusing their attention on finding the best possible solution. This study proposes, implements, and applies an efficient hybrid constriction coefficient particle swarm optimization-based butterfly optimization algorithm (HCCPSOBOA) by combining the properties of constriction coefficient particle swarm optimization (CCPSO) and butterfly optimization algorithm (BOA) to reduce the amount of energy required by a sensor node while simultaneously ensuring that all nodes are fully connected. The results that were obtained indicate that the approach that was proposed produces better results than those that were discovered in the literature utilizing the HCCPSOBOA algorithm in terms of the amount of energy that is saved and the reliability of the connectivity.

I. Satish Kumar and Kotte Sowjanya have contributed equally to this work.

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Keywords HCCPSOBOA · CCPSO · BOA · IoT · WSN · Energy saving · Full connectivity

Introduction

The Internet of Things (IoT) has developed into an essential today's component of the contemporary way of life [1]. Things, things, and more things, including devices that serve us daily, are required to do so in an efficient manner to communicate to bring comfort with relatively little human interaction and intervention. When it comes to communication between the nodes, efficiency in the use of energy is of the utmost significance. Therefore, it is necessary to come up with plans to guarantee that no energy will be wasted between signal transmission and reception and time that was wasted among various nodes. Nevertheless, a decreased amount of transmission energy causes problems with connectivity. As a result, researchers have been looking for possible solutions for a few years; they have been working on developing the most effective solution in which nodes have been known to send messages with minimal power come together to form a network that is completely connected [2, 3]. Energy-efficient antennas have been used in wireless local area networks (WLANs) to reduce power consumption, as documented in [4]. Another option is the wireless transfer of harvested power to the nodes for their power requirements [5]. IoT networks are becoming more and more diverse, creating new issues that necessitate the new study of prior solutions and the development of entirely new ones and also presented a survey that focuses on WSN battery life extension through control approaches and cluster selection [3]. Lack of efficiency in centralized connection methods is due to the additional

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communication overhead and delay that is required to gather and synchronize the flow of information from and to all coordinated nodes. However, it is critical to have a mathematical model for calculating how much power each node needs. A centralized control system for wireless sensor network (WSN) is a viable alternative since it provides full-area coverage with little energy requirements, and the central unit's high processing capabilities allow it to make a well-informed decision. WSNs can also benefit from a centralized hub, which provides numerous networking advantages, including optimal node placement and deployment, data aggregation, and energy-conscious clustering. Particle swarm optimization (PSO) is one of the techniques employed, and some of these ideas have been compiled. It has been shown that PSO is simple to implement, computationally efficient, and rapidly converging [6]. Otherwise, as discussed in [7], the most effective placement of sensor nodes could have been a time-consuming and computationally intensive operation. Network life can be extended by using clustered WSNs. Researchers typically build simple networks with clustered topology without any obstacles in mind [8]. Due to a surge in the demand for wireless data collection, a vast deployment of sensors in diverse areas is inevitable. Because of the high density of sensors and the fact that each one is self-contained, recharging them is difficult due to the associated logistical issues. As a result, a clustered WSN's energy efficiency becomes a critical factor in ensuring its long-term viability and reliability. Network dependability and energy efficiency are negatively impacted by communication overhead. Through the use of data aggregation, it is possible to reduce the energy required to communicate with a remote base station while still achieving the same level of performance [9]. Sensors in close proximity form a cluster for data gathering based on an efficient method for network structure.

Using PSO [10] developed a clustering technique that helps to reduce energy consumption in networks. These nodes have a much longer lifespan when elected by the PSO algorithm, which takes into account their remaining energy when selecting cluster heads (CHs). A con methodology was presented [11] to move mobile base stations in WSN networks more efficiently, longer, and with better data transmission. In light of the base station's mobility, the goal was to establish the method and position for data collection so that all sensor nodes can provide data to the base station via single hop communication. The PSO algorithm was used to find the best locations for the base station to visit depending on the distance between the base station and sensor nodes. The results show that the suggested protocol may greatly boost data delivery at the base station while also extending the network lifetime in comparison to other methods in the literature.

Particle swarm optimization has also been applied to a routing protocol to reduce energy consumption. Authors [12] explained how PSO can outperform the genetic algorithm when it comes to calculating cheaper energy paths.

Furthermore, authors [13] have considered the deployment of nodes to maximize coverage. Using the PSO algorithm, they are able to increase coverage without increasing the number of nodes.

Authors in [14] each node's transmission power is calculated using particle swarm optimization (PSO) to avoid establishing unconnected zones among sensors cluster. There is evidence that the proposed PSO algorithm is more energy efficient than the more usual use of nodes with only a single transmission power.

Electrostatic discharge algorithm (ESDA) [15] is a new algorithm that has been designed, implemented, and utilized to reduce the amount of energy that a sensor node requires while simultaneously ensuring that each node is fully connected. The results that were obtained indicate that the approach that was proposed, produces better results than those that were discovered in the literature utilizing the method of particle swarm optimization [15] in terms of the amount of energy that is saved and the reliability of the connectivity.

From the literature survey, it is evident that seeking a better solution for this particular engineering optimization problem is still open for further research and also observed that no such novel hybrid optimization algorithms were explored. This reason made our attempt to implement an efficient hybrid constriction coefficient particle swarm optimization based butterfly optimization algorithm (HCCPSOBOA) by combining the properties of constriction coefficient particle swarm optimization (CCPSO) and butterfly optimization algorithm (BOA) to minimize energy consumptions by energy usage by identifying the appropriate transmission power while simultaneously guaranteeing that the entire network is properly linked. To evaluate the savings in energy, a comparison will be made with other commonly used meta-heuristic optimization techniques.

The major contributions of this paper are as follows:

1. A hybrid optimization algorithm HCCPSOBOA has been developed and implemented for achieving the desired target.
2. To assess the efficacy of the proposed HCCPSOBOA for the selected problem, the outcomes of HCCPSOBOA have been quantitatively compared with HCCPSO and BOA algorithms.
3. To check the robustness of the proposed approach for the selected problem, a detailed statistical analysis has been presented.

Wireless Sensor Networks

Clustered WSNs

Extending the life of a WSN network is made possible through the use of clustering. In clustered WSNs, most classic routing approaches are based on the premise that no obstacles exist [8]. Sensor networks (WSN) are becoming increasingly popular for a variety of purposes, including generating reports on factors such as temperature and humidity, and light and chemical activity. This trend is expected to continue in the future. Observers (such as base stations) collect the sensor data that is sent forth.

Recharging WSNs is challenging because of the dense deployment and independent nature. As a result, improving the project's energy efficiency is a top priority. Data aggregation in these networks reduces communication network overhead, resulting in significant energy savings [9]. Sensors can be split into tiny groups termed clusters to assist data aggregation through an effective network organization. There is a headset and several member nodes in each cluster [16]. The flow of data in a networked cluster is shown in Fig. 1

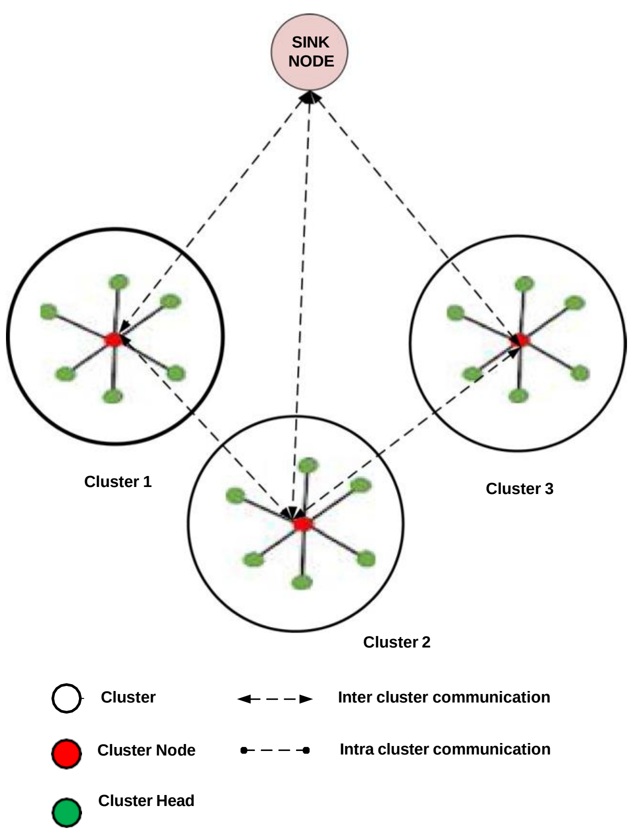

Fig. 1 Clustered wireless sensor networks topology

Energy Saving in WSNs

Due to the limited energy capacity of wireless sensors, they remain a research priority. WSN energy efficiency study was first conducted by Heinzelman et al. over a decade ago using clustering and beam forming to save needless transmissions has been recommended by them. There have been several advancements in sensor nodes since that time, including additional capabilities. As a result, despite the research field's maturity, this movement toward IoT will necessitate further research [17, 18].

The development of sensors and energy models is the first stage in coming up with ideas for ways to save energy. The CPU, the sensing unit, and the communication unit are the three subsystems that use battery power, according to ref [17]. In addition, the authors claim that many wireless node events can be tweaked to reduce power waste. Packet overhead, idle listening, overhearing, over-emitting, collisions, and state transitions are some of the most common causes of network congestion. By determining the best transmission power for each node in the network, researchers hope to minimize state transitions and connect all sensor nodes in a single cluster. For the time being, we won't be considering any of the other energy-wasting activities.

It may be possible to save energy by changing sensor states, even though doing so requires some of the sensor's energy. Energy savings can be achieved, for example, by putting the nodes into sleep mode, which disables the vast majority of their functions [19]. Because the focus of this research is on network connectivity, it will not take into account the various node states. Once the network link is established for stationary sensors, the next phase of the network goal can be to change modes.

Problem Emergence

The primary goal of this research is to locate each sensor node in a WSN in such a way that it consumes the least amount of power possible. While transmitting minimum power, sensors on the edge of the network tend to link to inward nearby sensors. As a result, sensors that are located between the network's edges and its core tend to give full connectivity in all directions. Computationally, it becomes hard to check every conceivable location that each sensor can take to ensure optimality as the network increases. Therefore, meta-heuristic search strategies are used to identify the best answer. The cost of calculation is sometimes sacrificed to achieve the best possible result.

Modeling of System

In this study, a single cluster of N wireless sensors is used to create a mesh network. Each measurement packet should be

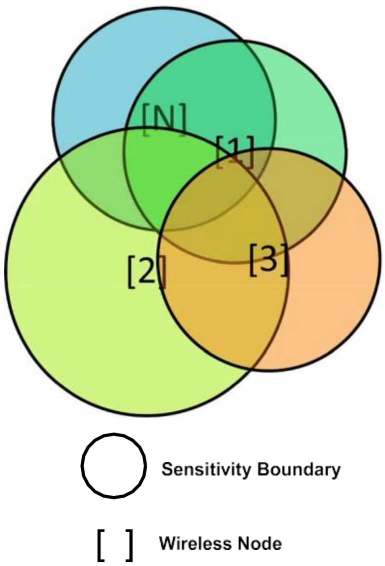

Fig. 2 System model

routed to a sink node to achieve this goal. Both sensor and sink nodes are contained within a square in the global neighbor matrix ‘Γ,’ and it is defined as the following:

$$\Gamma_{ij}(\gamma) = \begin{cases} 0, if\, \rho_j < \rho_{th} \\ 1, if\, \rho_j \geq \rho_{th} \end{cases} \tag{1}$$

There, $_i$ symbolizes the transmitting power of the node i while p_j specifies the power received by the node j. Receiver sensitivity is measured by p_{th}. Following Eq. (1), a signal is said to be connected between two nodes when the received power is greater than the receiver’s sensitivity when enough power is used to transmit the signal. As depicted in Fig. 2, the signal intensity in each node’s circular area is sufficient to ensure connectivity. Each circle’s signal intensity is p_{th}, which means that any receiver within this circular area will be able to pick up the signal.

$$\frac{P_R}{P_t} = \frac{A_r A_t}{d^2 \beta^2} \tag{2}$$

A receiver’s signal power P_R is proportional to the transmitter’s output power P_t, and d is the receiver’s distance from the transmitter. A_r and A_t represent the effective areas of receiving and transmitting antennas, respectively, and β represents the wavelength of the signal being sent in Eq. (2) referred to by the Friis formula [13]. A single isotropic transmission and reception antenna for each sensor node is employed to represent the antenna’s effective area $A_{isotropic}$ because this work is not focused on sensors’ antenna design.

$$A_{\text{isotropic}} = A_r = A_t = \frac{\beta^2}{4\pi} \tag{3}$$

So, Eq. (2) further simplified as:

$$\frac{P_R}{P_t} = \left(\frac{\beta}{4\pi}\right)^2 \tag{4}$$

Equation (1) is used to calculate the global neighbor matrix and then the algorithm decides the connected pair of nodes as described in the next section.

Checking of Network Full Connectivity

For a system to be considered fully connected, it must have at least one active connection link and be capable of forming an uninterrupted path, as illustrated in Fig. 3a. Fake fully connected networks are generated when each node has a single connecting link and cannot be connected individually, as depicted in Fig. 3b. Fully connectivity can be readily achieved and checked in small networks with a few nodes. However, the sheer number of nodes in a real IoT application makes figuring out how well each one is connected computationally which visually difficult.

The first step in determining connectivity is to calculate the Laplacian matrix of the global neighbor matrix Γ.   is the total number of nodes, and deg(n_i) is the number of other nodes connected to the i^{th} node, n_i:

$$L = \left[l_{ij} \right]_{nXn} \tag{5}$$

$$l_{ij} = \begin{cases} \deg(n_i)\ if\ i = j \\ -1\ if\ i \neq j \text{ and } \Gamma_{ij} = 1 \\ 0 \text{ otherwise} \end{cases} \tag{6}$$

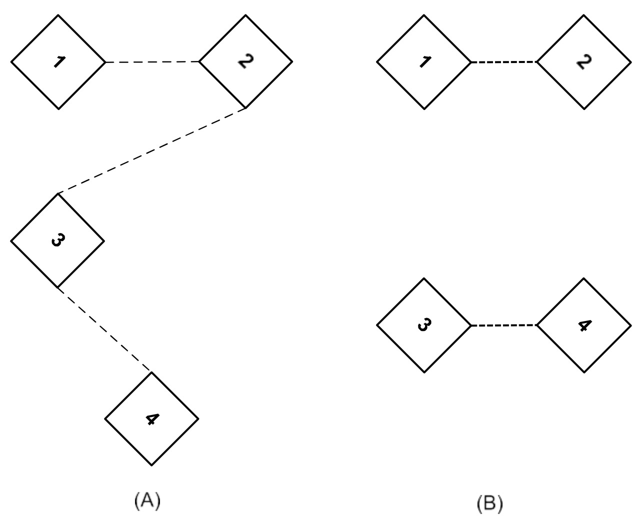

Fig. 3 **A** Fully connected network **B** Disconnected network

$$\deg\ n_i = \Gamma_{ij}^2 \longleftrightarrow i = j \quad (7)$$

There are nodes connected to i^{th} node if $i = j$, and the square of their neighbor matrix is equal to the number of nodes connected to i^{th} node. Eigenvalues of the Laplacian matrix are obtained using the following equation:

$$L.E = \psi.E \quad (8)$$

where E is a n × 1 eigenvector that meets all of the following conditions in Eq. (8). To construct a vector, each eigenvalue can be combined as ψ illustrated below:

$$\psi = \left(\psi_1, \psi_2, \psi_3, \ldots\ldots, \psi_n\right)^t \quad (9)$$

A fully connected state can only be achieved by having an ψ_2 that is positive, as shown by the notation $\psi_1 < \psi_2, < \psi_3 < \cdots < \psi_n$. It is also called algebraic connectivity of Γ and can be determined by looking at its second smallest Laplacian Eigenvalue ψ_2 and checking to see if there is at least one connection between each node. There must be sufficient transmission power for a fully connected network under these conditions.

Investigated Optimization Algorithms

Constriction Coefficient Particle Swarm Optimization (CCPSO)

In the field of swarm intelligence, PSO is a popular and widely used optimization technique. These behaviors are inspired by birds and fishes. PSO's optimization process relies on the inertia factor, *pbest*, and *gbest* operators, which are all found in the library. Note that the pbest and gbest parameters assist in locating the solution space's most feasible regions, whereas particle inertia aids in the search's overall scope. The location and trajectory of the particles change as the values of the particles change in successive iterations. Using Eqs. (9) and (10), the velocity v_x^d and position X_x^d of the particles are updated.

$$v_N^d(t+1) = w(t).v_N^d(t) + C_1.r_1.\left(\text{Pbest}_N - X_x^d(t)\right) + C_2.r_2.\left(\text{gbest} - X_N^d(t)\right) \quad (9)$$

$$X_N^d(t+1) = X_N^d(t) + v_N^d(t+1) \quad (10)$$

whereas C_1, C_2 are learning constants while r_1, r_2 are the numbers in the range of [0, 1]. Where is the inertia factor that adaptively changes its value during the iterative process =(Maxit − iter)/Maxit.

Because of the PSO particles moving outside the solution space during optimization, it has been found that candidate solutions are slowly converging toward feasible regions [20]. Due to a lack of particle utilization, constriction coefficients were introduced in PSO [21] to speed up particle exploitation. The following is a list of the CCPSO parameters:

$$\emptyset = \emptyset_1 + \emptyset_2 \text{ where, } \emptyset_1 = 2.05 \text{ and } \emptyset_2 = 2.05 \quad (11)$$

$$K = 2 \Big/ \left(\emptyset - 2 + \text{sqrt}\left(\emptyset^2 - 4\emptyset\right)\right) \quad (12)$$

The parameters $\varnothing_1$, $\varnothing_2$ *and* $\varnothing$ are used to control the path of the particles, while K is the constriction coefficient. In addition, the inertia factor, $w(t) = K$, the individual learning factor, $C_1 = K\varnothing_1$ and the social learning factor, $C_2 = K\varnothing_2$, and then the velocity Eq. (9) is rewritten as Eq. (13).

$$v_N^d(t+1) = K.v_N^d(t) + K\emptyset_1.r_1.\left(\text{Pbest}_N - X_N^d(t)\right) + K\emptyset_2.r_2.\left(\text{gbest} - X_N^d(t)\right) \quad (13)$$

For the PSO solution space to remain in equilibrium, the value $\varnothing$ must be greater than 4. Particles' convergence toward global optimums is directly related to the social and personal learning factors of their particle system, according to Eq. (13).

Butterfly Optimization Algorithm (BOA)

The foraging and mating behavior of the butterfly is modeled in a meta-heuristic algorithm called BOA [22–24]. When compared to other meta-heuristics, BOA [24–26] is distinguished by the fact that each butterfly has its distinct scent. The following is a possible formulation for the fragrance:

$$f = cI^a \quad (14)$$

According to this formula, represents the sensory modality, and I is the stimulus intensity; denotes the power exponent depending on the extent of fragrance absorption f.

Sensory modality index can theoretically be taken at any value in the range [0, ∞]. When it comes to the BOA [24–26], its value is decided by the specificity of the optimization problem. In the optimal search phase of the algorithm, the sensory modality can be expressed as follows:

$$c(t+1) = c(t) + 0.25 \big/ c(t) \cdot \text{Maxit} \quad (15)$$

Maxit is the maximum number of iterations, and is set to 0.01. In addition, the algorithm contains two crucial stages: a global search phase and a local search phase. For the global search movement of butterflies, we can formulate the mathematical model as follows:

$$X_N^d(t+1) = X_N^d(t) + \quad r^2.gbest - X_N^d(t) \quad .f_N \tag{16}$$

where is a random number in the range [0, 1] and X_N^d is the i^{th} butterfly's solution vector. In this case, *gbest* is the current best solution among all the existing solutions for the i^{th} butterfly and f indicates the fragrance. Local searches can be expressed as:

$$X_N^d(t+1) = X_N^d(t) + \quad r^2.X_j^d(t) \ - \ X_k^d(t) \quad .f_N \tag{17}$$

where, X_j^d and X_k^d are solutions of j^{th} and k^{th} butterflies, which are randomly selected from the solution space, respectively. This indicates that the butterfly performs a random walk if, X_j^d and X_k^d are in the same iteration. The solution will be more diverse if this kind of random walk is allowed to take place.

A butterfly's search for food and a mate can take place on a local and global scale. For this reason, a probability switch p is established to convert between the traditional global search and the intensive local search. A random number in the range [0, 1] is generated by the BOA in each iteration and compared with the probability switch p to decide if the search should be global or local.

Hybrid CCPSOBOA

Here, an efficient HCCPSOBOA is proposed, a mixture of independent CCPSO and BOA. When it comes to the generation of the new solution, CCPSO and BOA are vastly different. As a high-dimensional optimization issue gets more complex, the PSO method can only cover a limited area. Rather than using each algorithm individually, we combine the capabilities of both and do not employ each algorithm sequentially. In other words, the two algorithms are heterogeneous because of the approach used to get the final output. The steps for the hybrid CCPSOBO algorithm are as follows:

Step 1: Initialize the algorithm parameters like N number of agents, d dimension of the problem *Maxit* maximum number of iterations, P probability switch, power exponent, sensor modality index, $\varnothing_1$ $\varnothing_2$ control parameters, and r_1, r_2 are the random numbers in the range of [0, 1].

Step 2: Start the procedure with a randomly generated initial position and velocity of agents (butterflies). For example, if the entire number of agents is N and d is the total number of decision variables (number of sensors) in the hyperspace, then using Eq. (18):

$$x_N^d = x_{\min,d} + \quad x_{\max,d} - x_{\min,d} \quad * \text{rand} \tag{18}$$

$x_{\max,d}$ and $x_{\min,d}$ are maximum and minimum limits for decision variable (sensor power transmission range) and rand () is a random number between 0 and 1. Similarly, an initial velocity of agents is to be generated using Eq. (19).

$$v_N^d = v_{\min,N} + \quad v_{\max,N} - v_{\min,N} \quad * \text{rand}() \tag{19}$$

Step 3: Evaluate the agent's fitness value using Eq. (2) and check for full connectivity using Eqs. (5)–(9)and record the *gbest* vector so far. Set iteration count t as zero.

Step 4: Determine the fragrance f of each agent using Eq. (14).

Step 5: Perform a search using Eq. (16) (solution moves towards best position) if $r < P$ or using Eq. (17) (move randomly) if $r > P$ where $r \in [0, 1]$

Step 6: Update the velocity of agents using Eq. (13) and the position of agents using Eq. (10).

Step 7: Evaluate the new agent's fitness value using Eq. (2) check for full connectivity using Eqs. (5)–(9)

Step 8: Record the *gbest* vector so far if new fitness is better than *gbest* otherwise preserve as it is.

Step 9: Update the sensory modality index using Eq. (15).

Step 10: Enforce the stopping criterion if the maximum number of iterations is reached (Maxit) otherwise repeat Step 4 to Step 9.

Step 11: Print the optimal solution and respective fitness.

Results and Discussions

The transmission power of − 30 dBm has been chosen as the minimum for the experiments. The maximum power is set to offer a connection across a distance of 28.284 [m] within the random distribution area, while the transmission frequency is set to provide the lowest possible attenuation in the frequency range of 915 MHz, which is generally utilized in WSN applications. Finally, the sensitivity, which is defined as the lowest received power that supports information recovery, is set at − 60 dBm. Table 1 lists all the parameters used in this investigation. There are only 10 possible scenarios according to [14]. However, scenarios 1 and 3, scenarios 2 and 5, scenarios 4 and 6, and scenarios 7 and 9 are identical. As a result, in this paper total scenarios are

Table 1 WSN parameters used for the simulation

Parameter	Value
Number of sensor nodes	20
Sensor transmission power range	–30 dBm
Sensor transmission power frequency (f)	915 MHZ
Area for sensors random locations (LXL)	20 × 20 m
Sensor sensitivity (p_{th})	–60 dBm

reduced from 10 to 6. The experiments were carried out on the same platform. MATLAB 2022a, running on Windows 10 (64-bit), with an Intel (R) Core (TM) i5-5000 processor clocked at 2.9 GHz and 8 GB of RAM, was used to compare the output of each algorithm.

HCCPSOBOA, BOA, and CCPSO methods have been developed and applied to the scenarios studied in [14]. As illustrated in Figs. 4, 5, 6, 7, 8 and 9, there were six different scenarios in the paper, each with 20 sensors dispersed across a 20 m^2 area. Various well-known algorithms, such as particle swarm optimization (PSO), simple method (SM), electrostatic discharge algorithm (ESDA), genetic algorithm (GA), differential evolution (DE), black hole (BH) algorithm, electromagnetism-like algorithm (EM), salp swarm algorithm (SSA), and sine cosine algorithm (SCA), have been examined for comparison purposes. However, it is worth noting that there are only ten possibilities in [14]. From Figs. 4, 5, 6, 7, 8 and 9, it is observed that for all

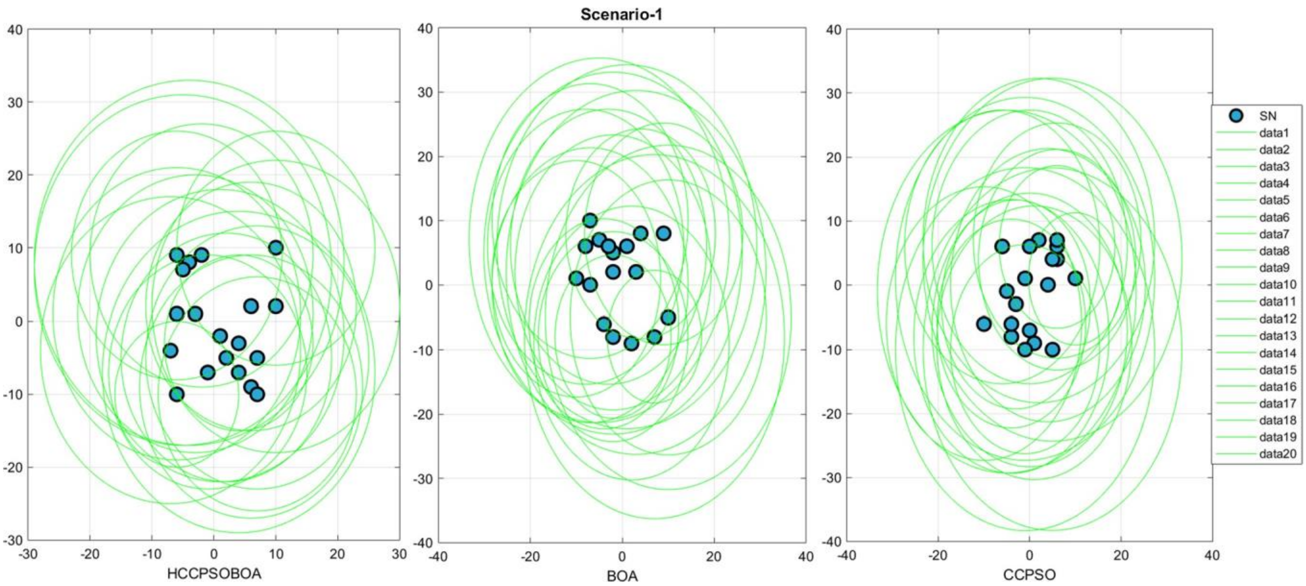

Fig. 4 Optimal sensor node deployment obtained by HCCPSOBOA, BOA and CCPSO for Scenario 1 in a square area of 20×20 m with 20 sensors

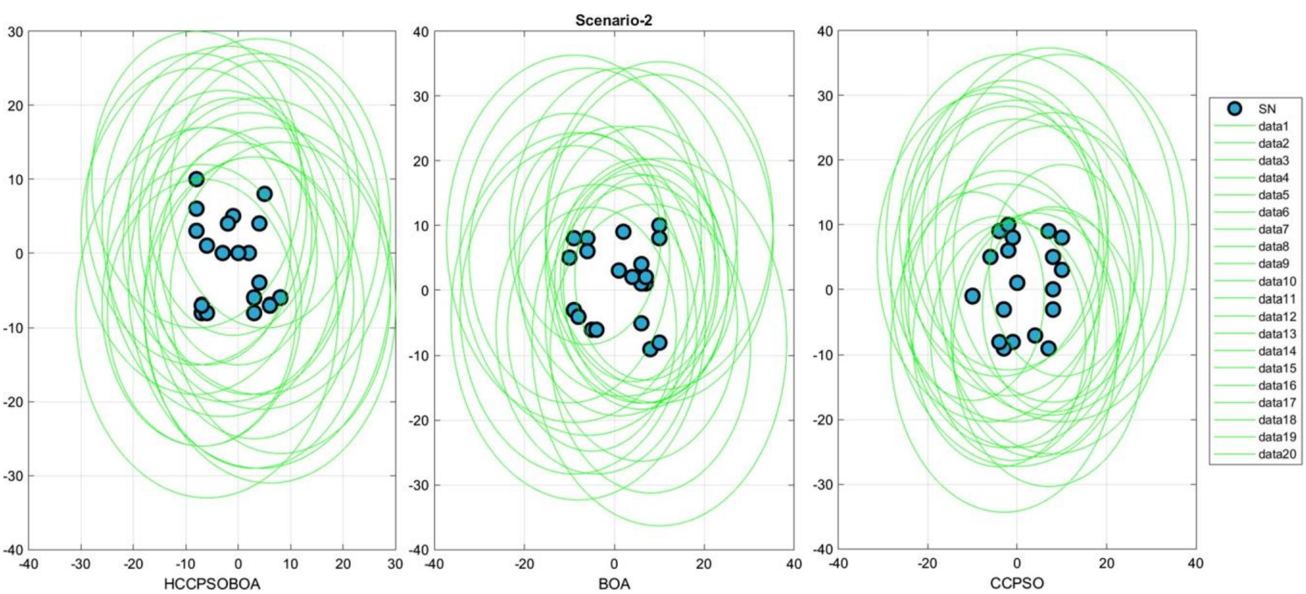

Fig. 5 Optimal sensor node deployment obtained by HCCPSOBOA, BOA and CCPSO for Scenario 2 in a square area of 20×20 m with 20 sensors

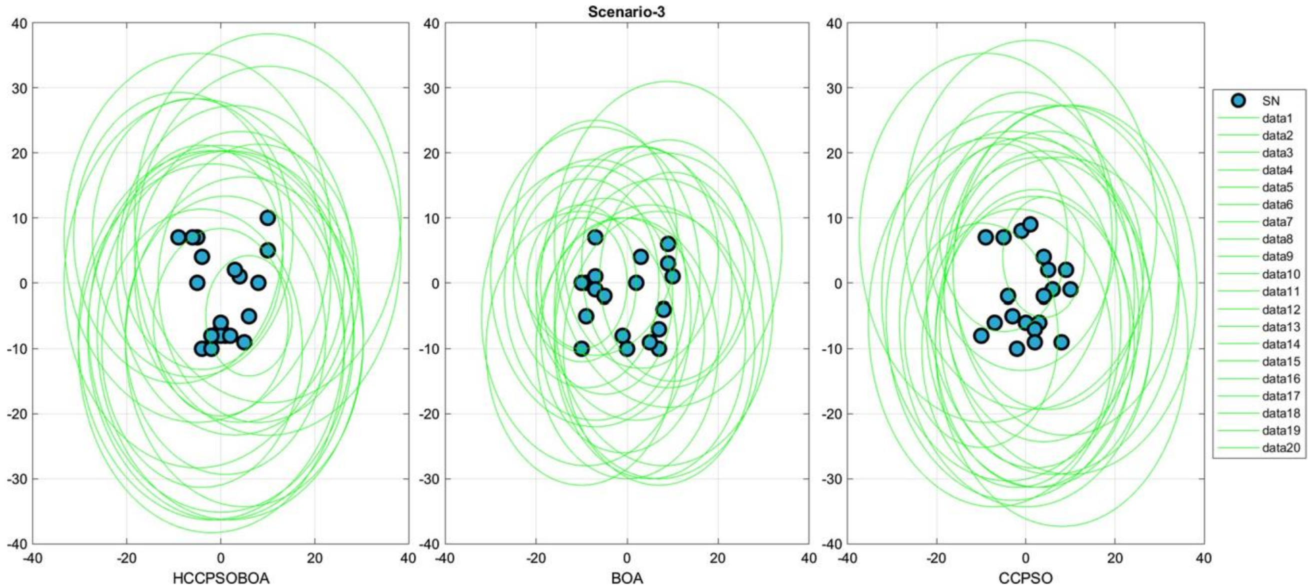

Fig. 6 Optimal sensor node deployment obtained by HCCPSOBOA, BOA and CCPSO for Scenario 3 in a square area of 20 × 20 m with 20 sensors

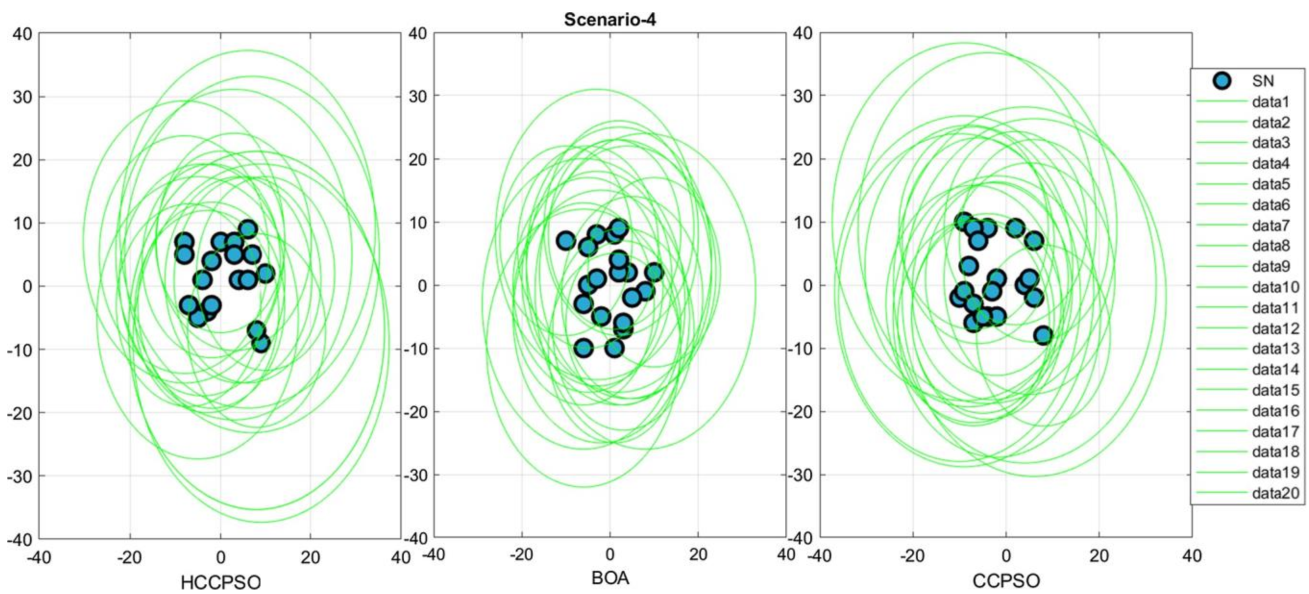

Fig. 7 Optimal sensor node deployment obtained by HCCPSOBOA, BOA and CCPSO for Scenario 4 in a square area of 20 × 20 m with 20 sensors

six scenarios the HCCPSOBOA, BOA, and CCPSO algorithms deployed 20 sensor nodes within the confined area of 20 m^2. And it is also observed that the power transmission range of deployed sensors by investigated methods is within the considered range of − 30 dBm. Setting algorithm parameters is a critical step in addressing any optimization problem. Parameter sensitivity analysis (parameter tuning) is performed before the HCCPSO, BOA, and CCPSO algorithms are executed and then values are allocated, as shown in Table 2.

For a fair comparison, each scenario has been run 20 times by HCCPSOBOA, BOA, and CCPSO algorithms, and the best results are presented in Table 3. From Table 3 it is clear that the CCPSO results are almost very close to ESDA results and the results of BOA are marginally better than ESDA results. But the results of HCCPSOBOA are magnificent when compared to BOA, CCPSO,

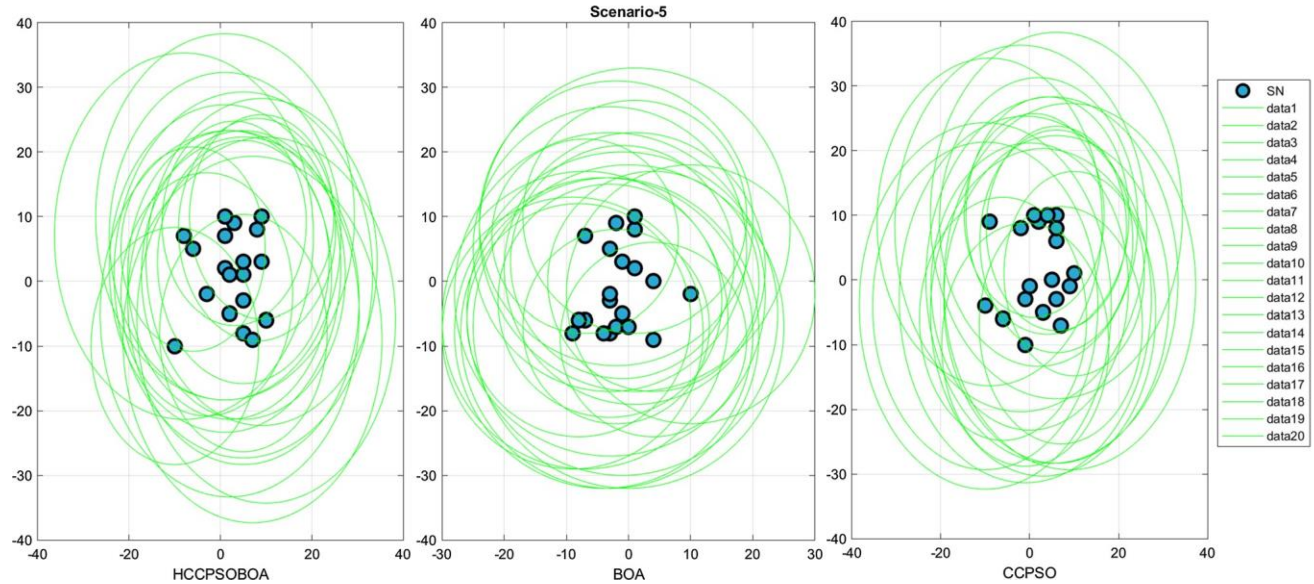

Fig. 8 Optimal sensor node deployment obtained by HCCPSOBOA, BOA and CCPSO for Scenario 5 in a square area of 20 × 20 m with 20 sensors

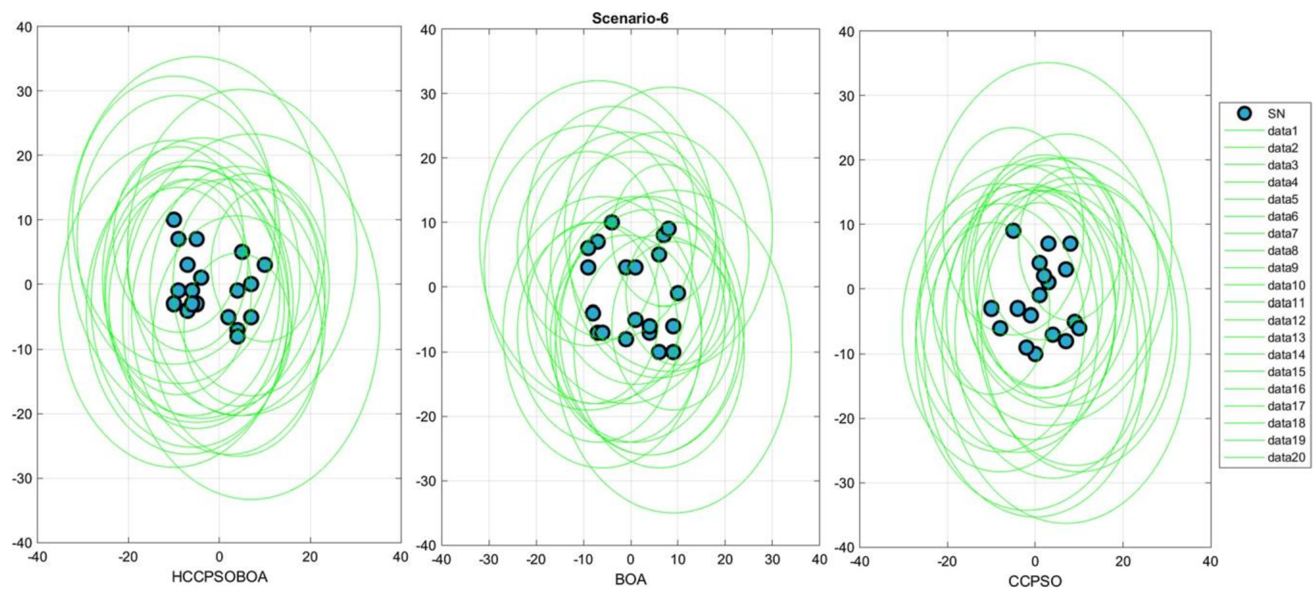

Fig. 9 Optimal sensor node deployment obtained by HCCPSOBOA, BOA and CCPSO for Scenario 6 in a square area of 20 × 20 m with 20 sensors

ESDA, and all other existing results. The best results obtained by HCCPSOBOA for all scenarios are bolded in Table 3. The reason was very clear except for HCCPSOBOA all other experimented algorithms were performed alone according to their evolution strategy. The best values marked by HCCPSOBOA are − 5.866 dBm, – 8.613 dBm, − 6.947 dBm, − 5.949 dBm, − 7.973 dBm and − 5.390 dBm for scenarios 1 to 6, respectively, and among all algorithms BH and EM are poorly performed. The main reason is that HCCPSOBOA is a hybrid algorithm that takes advantage of the diverse nature of BOA and convergence capability of CCPSO for solving high-dimensional optimization problems. For better understanding, the results in Table 3 are presented in graphical form in Fig. 10.

Sketches of convergence curves obtained from the implemented HCCPSOBOA, BOA, and CCPSO algorithms for each scenario are shown in Figs. 11, 12, 13, 14, 15 and

Table 2 CCPSOBOA algorithm parameters

Algorithm	Parameter	Description	Assigned value
HCCPSOBOA	Φ_1, Φ_2	Control parameters	2.05
	N	Number of agents	50
	d	Dimension	20
	Maxit	Maximum number of iterations	1000
	c	Sensory modality index	0.01
	a	Power exponent	0.1
	p	Probability switch	0.5
	V_{max}, V_{min}	Velocity limits for agents	5, −5

Table 3 Results comparison using different algorithms

Scenario	Minimum transmission power achieved (dBm)											
	HCCPSOBOA	BOA	CCPSO	ESDA	PSO	SM	DE	GA	BH	EM	SSA	SCA
Scenario 1	**−5.866**	−5.184	−5.020	−5.044	−3.624	2.827	−4.026	−0.343	Inf	Inf	−0.4074	4.353
Scenario 2	**−8.613**	−7.857	−7.684	−7.683	−6.669	−2.699	−6.758	−1.090	−6.798	7.214	−5.841	7.636
Scenario 3	**−6.947**	−6.504	−6.261	−6.260	−3.353	2.827	−5.725	−2.499	−5.112	5.878	−5.161	7.610
Scenario 4	**−5.949**	−5.415	−5.021	−5.044	−5.113	3.842	−4.014	−0.529	−4.281	Inf	−3.389	8.473
Scenario 5	**−7.973**	−7.458	−7.281	−7.288	−6.669	−2.744	−6.475	−1.639	−6.031	3.445	−3.400	5.682
Scenario 6	**−5.390**	−4.763	−4.495	−4.507	−5.226	3.865	−3.363	−1.766	Inf	Inf	−0.541	6.532

Bold values represents the best solution

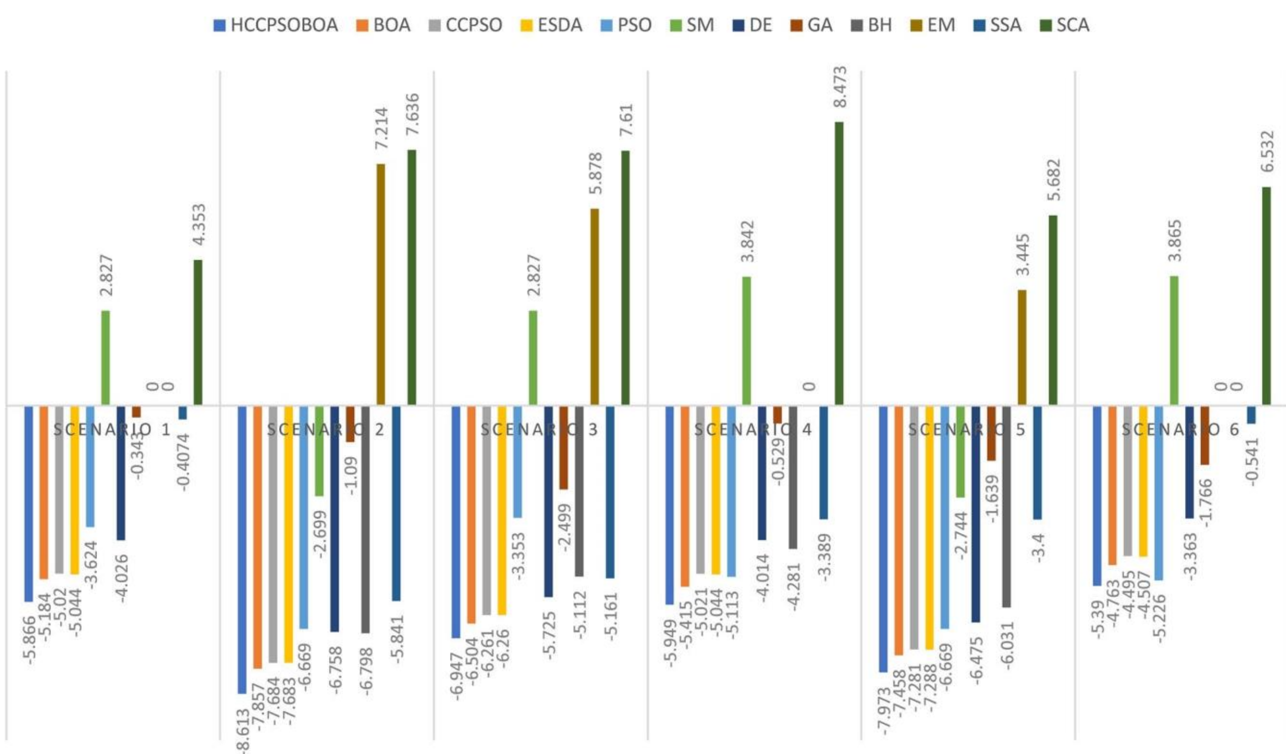

Fig. 10 Comparison of sum of all sensor nodes transmission power obtained by different algorithms

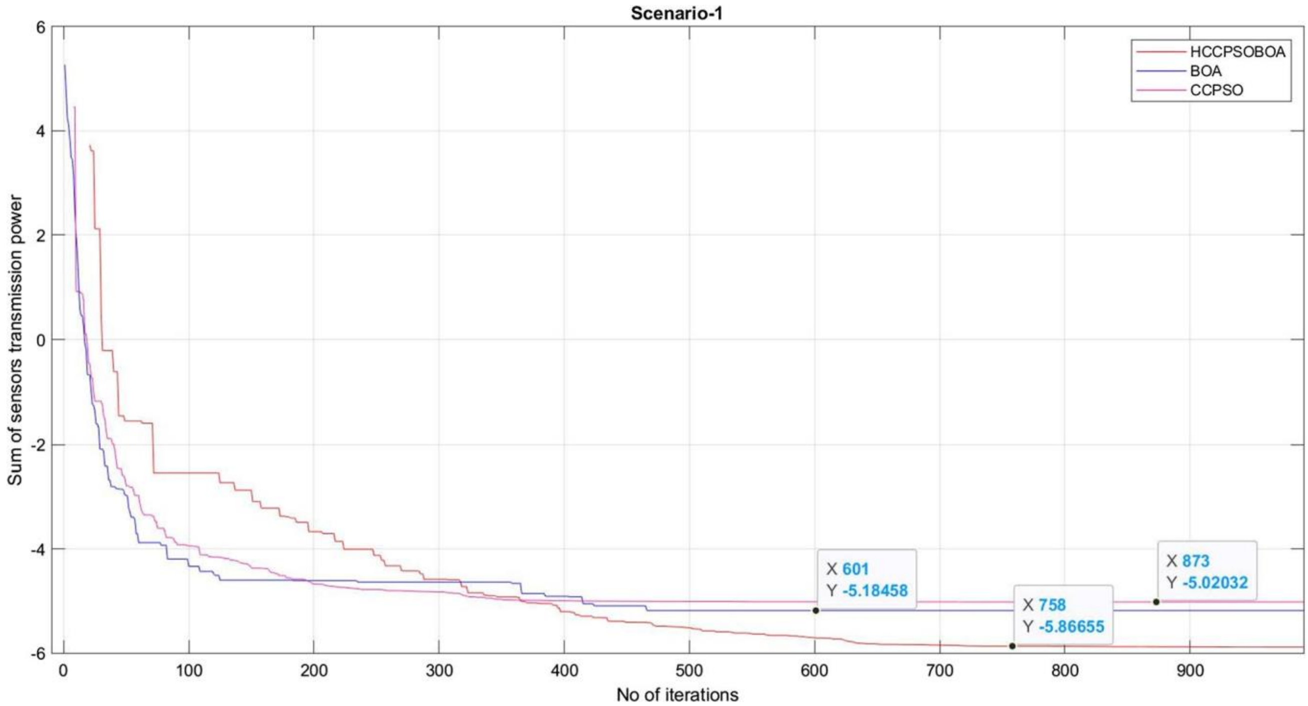

Fig. 11 Comparison of convergence characteristics of investigated algorithms for the Scenario 1

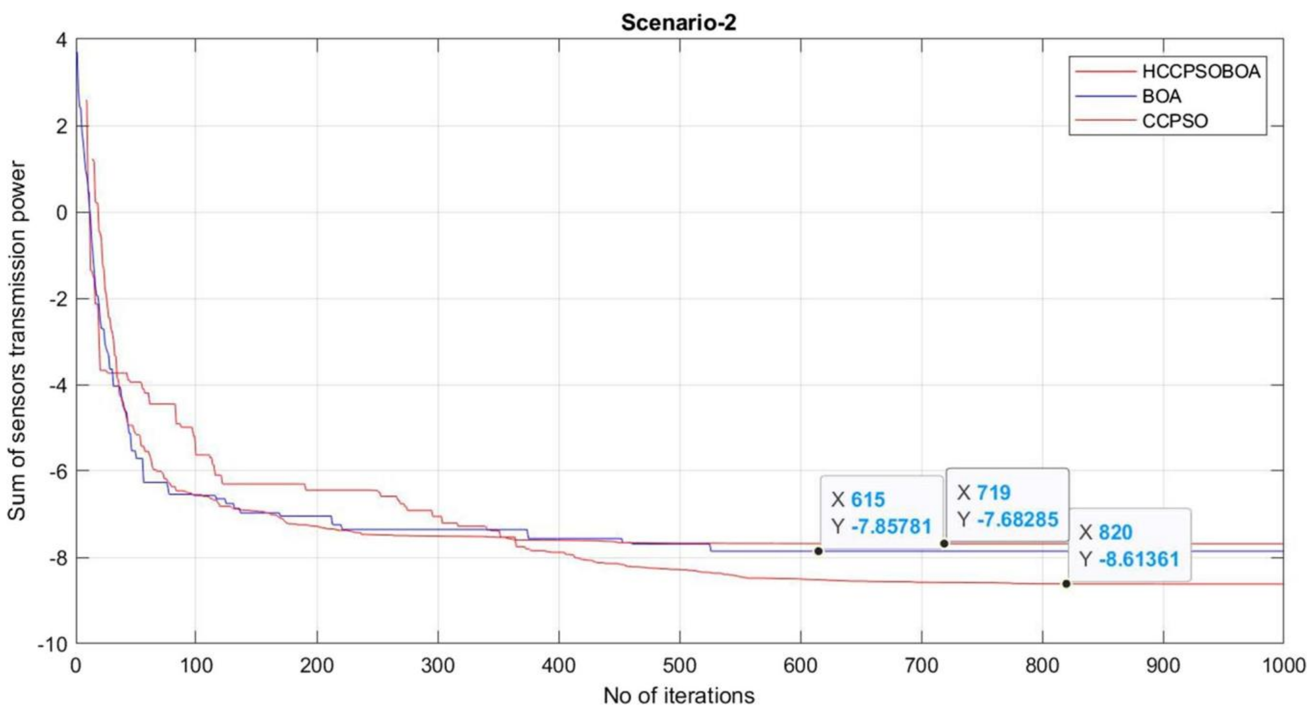

Fig. 12 Comparison of convergence characteristics of investigated algorithms for the Scenario 2

16. The number of iterations and the objective function value are shown on the *x*- and *y*-axes, respectively. The following observations can be drawn from Figs. 11, 12, 13, 14, 15 and 16. For scenario 1, HCCPSOBOA algorithm converged the best solution at the 728th iteration while BOA and CCPSO are at 466 and 430, respectively.

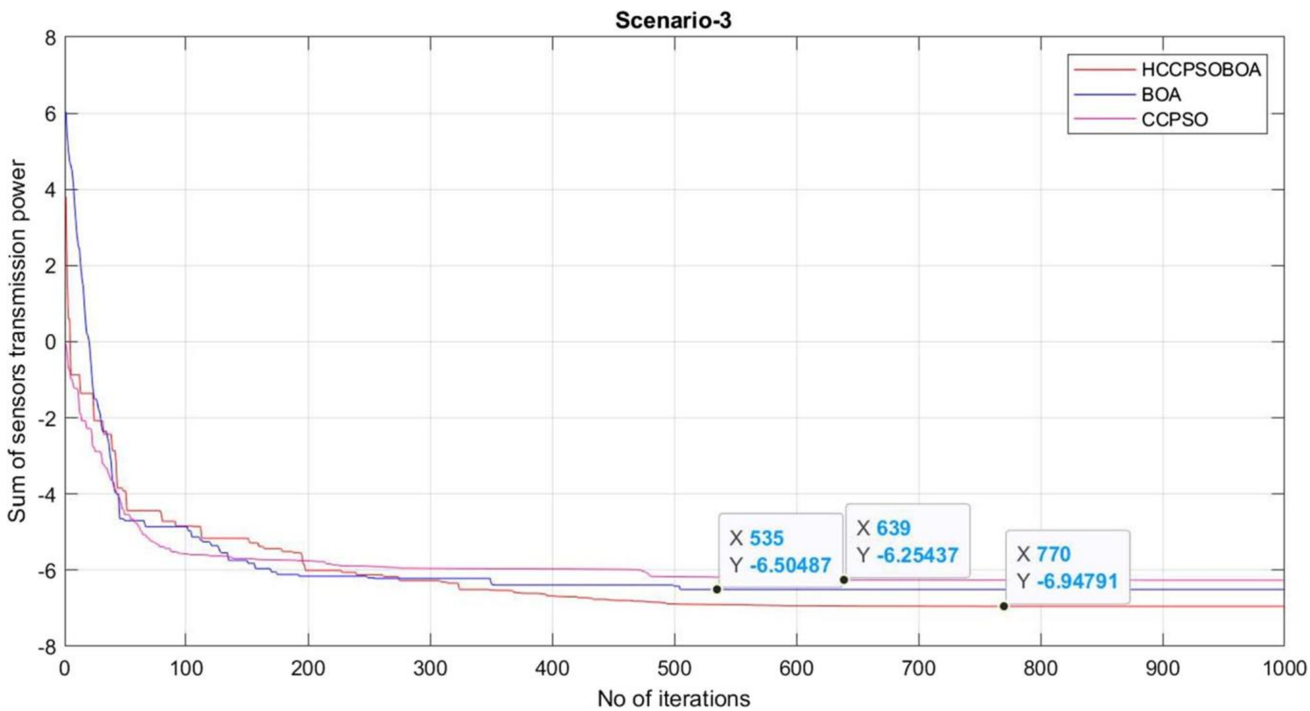

Fig. 13 Comparison of convergence characteristics of investigated algorithms for the Scenario 3

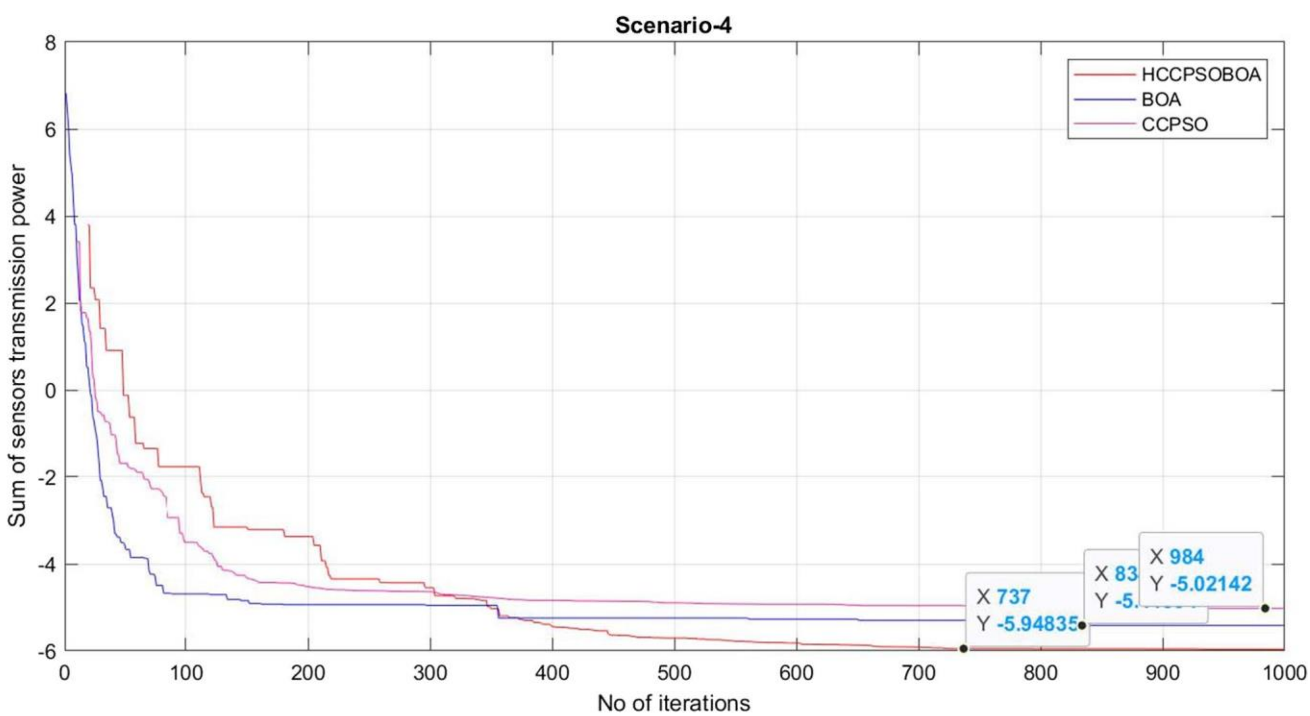

Fig. 14 Comparison of convergence characteristics of investigated algorithms for the Scenario 4

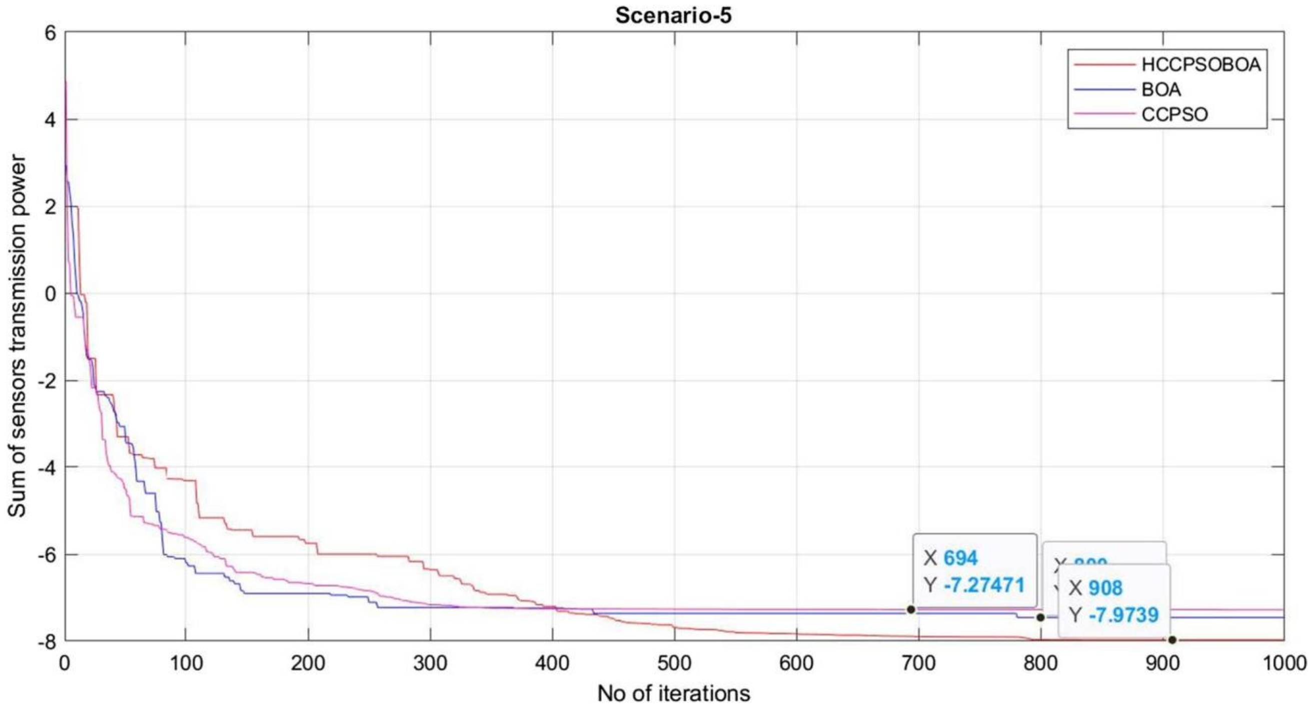

Fig. 15 Comparison of convergence characteristics of investigated algorithms for the Scenario 5

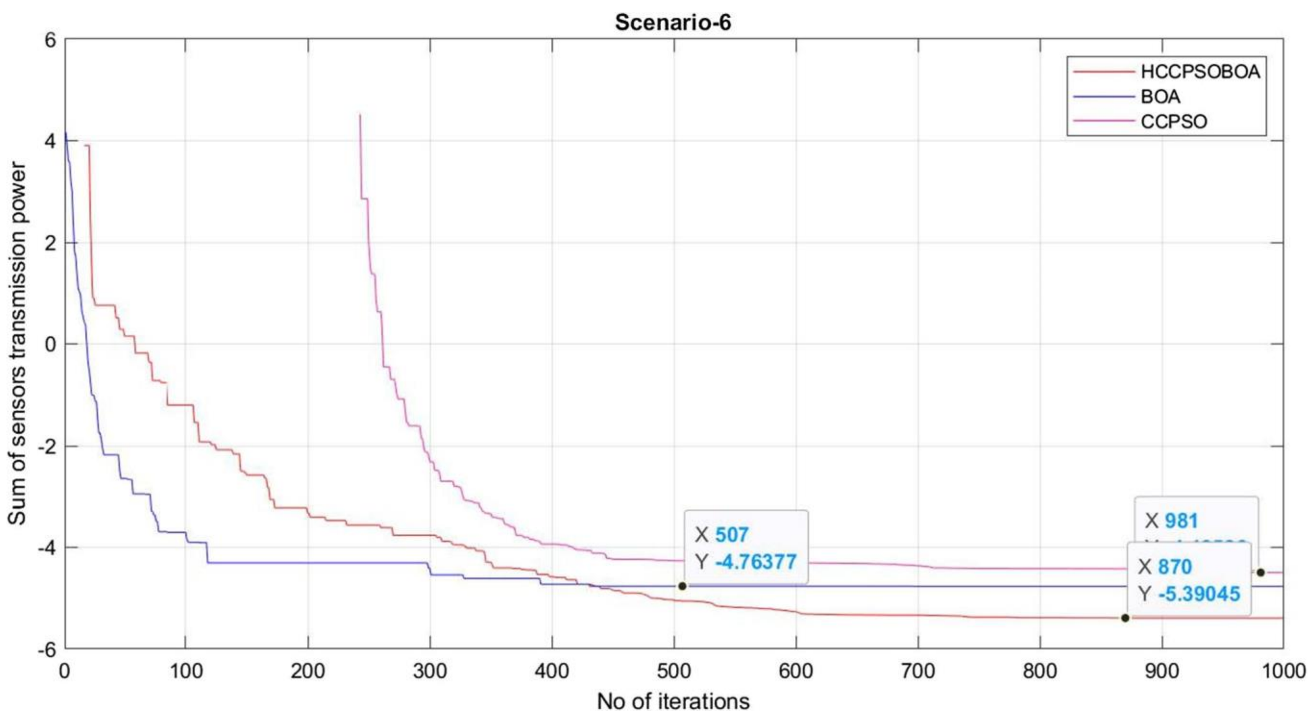

Fig. 16 Comparison of convergence characteristics of investigated algorithms for the Scenario 6

Table 4 Each sensor transmission power for six different scenarios obtained by CCPSO, BOA and HCCPSOBOA

	Scenario																	
	CCPSO						BOA						HCCPSOBOA					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Sensor 1	−17.2	−18.3	−21.3	−25.9	−25.3	−14	−17.6	−18.7	−21.8	−26.3	−25.7	−14.7	−17.9	−19.2	−21.9	−26.7	−25.9	−15.1
Sensor 2	−21.3	−25.3	−28.3	−15.3	−28.3	−16	−21.7	−25.7	−28.8	−15.7	−28.7	−16.4	−22.0	−26.2	−28.9	−16.1	−28.9	−16.8
Sensor 3	−16.3	−21.3	−28.3	−28.2	−22.3	−25	−16.7	−21.7	−28.8	−28.6	−22.7	−25.7	−17.0	−22.2	−28.9	−29.0	−22.9	−26.1
Sensor 4	−28.3	−16.3	−28.3	−27.8	−18.3	−19	−28.7	−16.7	−28.8	−28.2	−18.7	−19.2	−29.0	−17.2	−28.9	−28.6	−18.9	−19.6
Sensor 5	−25.3	−19.3	−21.3	−15.3	−22.2	−19	−25.7	−19.7	−21.8	−15.7	−22.6	−19.2	−26.0	−20.2	−21.9	−16.1	−22.8	−19.6
Sensor 6	−12.6	−25.3	−22.3	−16	−17.2	−22	−13.0	−25.7	−22.8	−16.4	−17.6	−22.7	−13.3	−26.2	−22.9	−16.8	−17.8	−23.1
Sensor 7	−18.3	−21.3	−28.3	−16.3	−15.7	−25	−18.7	−21.7	−28.8	−16.7	−16.1	−25.7	−19.0	−22.2	−28.9	−17.1	−16.3	−26.1
Sensor 8	−16.3	−16	−14.4	−28.3	−28.3	−22	−16.7	−16.4	−14.9	−28.7	−28.7	−22.7	−17.0	−16.9	−15.0	−29.1	−28.9	−23.1
Sensor 9	−21.3	−18.8	−28.3	−16.3	−28.3	−28	−21.7	−19.2	−28.8	−16.7	−28.7	−28.7	−22.0	−19.7	−28.9	−17.1	−28.9	−29.1
Sensor 10	−21.3	−22.3	−25.3	−14.3	−28.3	−13	−21.7	−22.7	−25.8	−14.7	−28.7	−13.7	−22.0	−23.2	−25.9	−15.1	−28.9	−14.1
Sensor 11	−28.3	−28.2	−28.3	−17.2	−25.3	−21	−28.7	−28.6	−28.8	−17.6	−25.7	−21.4	−29.0	−29.1	−28.9	−18.0	−25.9	−21.8
Sensor 12	−28.3	−28.3	−28.3	−28.3	−25.3	−28	−28.7	−28.7	−28.8	−28.7	−25.7	−28.5	−29.0	−29.2	−28.9	−29.1	−25.9	−28.9
Sensor 13	−21.3	−15.8	−9.2	−27.8	−28.3	−19	−21.7	−16.2	−9.7	−28.2	−28.7	−19.7	−22.0	−16.7	−9.8	−28.6	−28.9	−20.1
Sensor 14	−21.3	−25.3	−28.3	−18.3	−15.8	−22	−21.7	−25.7	−28.8	−18.7	−16.2	−22.7	−22.0	−26.2	−28.9	−19.1	−16.4	−23.1
Sensor 15	−28.3	−22.3	−25.3	−22.3	−15.8	−22	−28.7	−22.7	−25.8	−22.7	−16.2	−22.7	−29.0	−23.2	−25.9	−23.1	−16.4	−23.1
Sensor 16	−10.3	−28.3	−21.3	−22.3	−18.8	−19	−10.7	−28.7	−21.8	−22.7	−19.2	−19.7	−11.0	−29.2	−21.9	−23.1	−19.4	−20.1
Sensor 17	−21.3	−22.3	−28.3	−18.8	−28.3	−19	−21.7	−22.7	−28.8	−19.2	−28.7	−19.6	−22.0	−23.2	−28.9	−19.6	−28.9	−20.0
Sensor 18	−28.3	−28.3	−22.3	−15.3	−18.8	−22	−28.7	−28.7	−22.8	−15.7	−19.2	−22.7	−29.0	−29.2	−22.9	−16.1	−19.4	−23.1
Sensor 19	−16.3	−22.3	−17.2	−16	−18.3	−19	−16.7	−22.7	−17.7	−16.4	−18.7	−19.2	−17.0	−23.2	−17.8	−16.8	−18.9	−19.6
Sensor 20	−21.3	−7.7	−6.3	−5	−25.3	−17	−21.7	−8.1	−6.8	−5.4	−25.7	−17.6	−22.0	−8.6	−6.9	−5.8	−25.9	−18.0
Avg. Trans. Power	−21.6	−21.6	−23.6	−19.7	−22.7	−21	−21.6	−22.0	−23.8	−20.1	−23.1	−21.1	−22.3	−22.5	−23.9	−20.5	−23.3	−21.5

Table 5 Wilcoxon's Statistical analyses of 20 executions for each of scenario *P*: probability of statistic, *h* = 0 indicates null hypothesis cannot be rejected

Scenario Number	HCCPSOBOA vs BOA		HCCPSOBOA vs CCPSO		HCCPSOBOA vs ESDA		HCCPSOBOA vs PSO	
	P	*h*	*P*	*h*	*P*	*h*	*P*	*h*
1	< < 0.05	1	< < 0.05	1	0.6987	0	< < 0.05	1
2	< < 0.05	1	< < 0.05	1	< < 0.05	1	0.8625	0
3	< < 0.05	1	< < 0.05	1	< < 0.05	1	< < 0.05	1
4	< < 0.05	1	< < 0.05	1	< < 0.05	1	< < 0.05	1
5	< < 0.05	1	< < 0.05	1	< < 0.05	1	< < 0.05	1
6	0.6541	0	0.6725	0	0.6478	0	0.7015	0
Sig. Diff		5		5		4		4

For scenario 2, HCCPSOBOA, BOA, and CCPSO are converged at 755, 527, and 453, for scenario 3, HCCPSOBOA, BOA and CCPSO are converged at 707, 509, and 481, for scenario 4, HCCPSOBOA, BOA and CCPSO are converged at 730, 649, and 643, for scenario 5, HCCPSOBOA, BOA and CCPSO are converged at 860, 781, and 462 and for scenario 6, HCCPSOBOA, BOA and CCPSO are converged at 870, 395, and 778, respectively. The average convergence for HCCPSOBOA, BOA, and CCPSO is at 775, 554, and 541 iterations, respectively. The average convergence time for BOA and CCPSO are 5.22 s and 5.61 s, respectively, whereas HCCPSOBOA is 10.54 s because of the hybrid evolutionary process. Table 4 summarizes the HCCPSOBOA, BOA, and CCPSO-derived sensor transmission powers for the various scenarios under consideration. Each sensor has a different transmission power than the other sensors. The transmission power varies from scenario 1 to scenario 6 depending on the scenario. The average minimum and maximum sensor transmission powers from scenarios 1 to 6 are -20.5 dBm and − 23.9 dBm for HCCPSOBOA, − 20.1 dBm and − 23.8 dBm for BOA, and 21 dBm and 23.6 dBm for CCPSO algorithms.

Statistical Analysis

Wilcoxon's rank-sum test, which incorporates alternative and null hypotheses, is used to evaluate the efficacy of various statistical analysis methodologies. The null hypothesis represents the absence of a significant difference, while the alternative represents the presence of a significant difference. In other words, if the null hypothesis is accepted at a substantial level ($P > 0.05$), then the alternative hypothesis is accepted. Table 5 displays the results of Wilcoxon's rank-sum test for each method. Table 5 shows that HCCPSOBOA and BOA are significantly different from than CCPSO and ESDA algorithms in this study. Furthermore, the methods are compared based on their computational complexity to ensure a fair comparison.

Computational Complexity

The computational complexity of HCCPSOBOA is $O(t(N \times D))$ where *t* represents the number of iterations, *D* shows the number of variables, and *N* indicates the number of solutions (population size). This computation complexity is equal to that of CCPSO, BOA, GA, DE, EM, and SCA. However, the computational complexity of SSA is $O(t(N \times \log(N)))$ in the average case and $O(t(N^2)$ in the worst case, and for BH is $O(t(N^2 \times D)$. This means that the computational complexity of SCA and BH is worse than those of other algorithms due to the sorting of solutions in every iteration.

Conclusions

An HCCPSOBOA approach is presented in this paper by combining the properties of CCPSO and BOA to determine the transmission power of various sensor nodes to conserve sensor energy while maintaining all nodes fully connected. The HCCPSOBOA approach could save as much as 1 dBm of total network transmission power when compared to a sensor system that uses a continuous power supply. This proposed hybrid algorithm has been compared to CCPSO, BOA, PSO, GA, DE, BH, EM, SSA, and SCA in the literature, and the results are magnificently satisfactory. The HCCPSOBOA has outperformed other examined algorithms in all six scenarios. The HCCPSOBOA has always been able to find a solution in every scenario (i.e., to find a fully connected network). Other wireless technologies, such as WiFi, WiMax, Zigbee, and Bluetooth, may be supported in the future by adding additional frequencies. Energy saving and network connection are also evaluated by incorporating transmission rates and power usage into the order. And the search for a better solution for this engineering optimization problem is still on because a lot of efficient hybrid variants of optimization algorithms are still evolving.

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Declarations

Conflict of interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Smart Agriculture Monitoring System Using IoT

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Abstract

Agriculture plays an important role in the development of any country. Around 70–75% of the Indian population depend on agriculture and 1/3rd of the capital of the country comes through farming. There have been several issues in concern with agriculture that were hindering the growth and development of the country due to migration of the people from rural to urban. To overcome this problem, the paradigm is toward smart agriculture using several techniques like Internet of Things and big data analysis. These technologies have emerged and modified the cultivation system. By incorporating sensors that study the environment humidity, temperature make cultivation possible by saving farmers time and effort by adding sensors. With the application of IoT, it is anticipated that 28 billion things are going to be connected through Internet and one such being agriculture. The present system is implemented for smart farming using Internet of Things (IoT) sensors, thereby gathering information about the conditions of the crop needs and automatically controlling resulting in improved yield and efficient crop, and the work is implemented using Arduino Uno along with temperature, moisture, soil dryness, and rainfall detector. Using this system, one can monitor from any location and carry out cultivation.

Keywords

IoT Arduino Uno Wi-Fi module Sensors