Research Statement

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My Approach to Research

Since childhood, I was always interested in Computing and Machines cum solving complex-problems. I started my journey with computing when I was 8 Years old, when I taught myself programming by typing in programs and making small projects. To my mind, computers were a source of endless possibilities; whatever I could conceive, I could build. Over thirty years later, I still have the same enthusiasm. My interest in computer science research is fundamentally driven by the desire to build smart computing systems- faster, more reliable, secure, sustainable and above all autonomous, that make new things possible, everything looking magical and to support others to help and perform activities.

I love challenges. Nothing satisfies me more than coming up with an elegant solution to a difficult problem. I was fortunate enough to have a solid foundation in theory and practical demonstration of computers and information technology in Masters of Computer Applications from Punjabi University and later by Ph.D from Desh Bhagat University, India. I find theory and formalism indispensable in clarifying ideas, finding unseen corner cases, suggesting new directions to explore, and in the fundamental understanding of any problem.

The combination of engineering theory attached me first to the world of Compilers, Programming, Data Structures and Automata. It is one of the areas in computer science where theoretical results are very often put into practice. Also working in compilers and programming languages, can also improve the existing systems functionalities and make them run better and perform tasks in highly efficient manner. I applied improvements in tons of programs, and impact increased at varied levels. Finally, many challenges problems in terms of compiler design, algorithm analysis and NP-Hard problems can be solved.

My approach towards research is influenced by two-fold approach: Mix of Engineering and Theory. When I search a new research problem, I take a deep dive in thinking about the problem by building some prototype ideas and idea to better understanding and think of steps to solve the problems. After I understand the foundations, I research and learn what others have published and proposed solutions to those problems. With that, I can find and justify that my solution is better and whether the proposed approach from my side is better as compared to existing approaches. After that, I start implementing. My first attempt is rarely successful, but my experience in building the implementation quickly exposes what the real issues are. Then, I throw away my first implementation and use what I have learned to do it right. Finally, after

I have a working implementation, I sit down and try to document and formalize the ideas. I feel it is important to have a working implementation that you can experiment with before you formalize the system because otherwise your formulation may not match reality or miss some key subtleties.

The process of documentation and formalization often suggests new ways of simplifying or improving the implementation and exposes corner cases that I would not have considered. Thus, both engineering and theory play complementary roles in my approach to research.

Finally, I believe strongly in the openness of research and the free flow of ideas. I find communication with others invaluable in the development and understanding of research ideas. Most of my research ideas were not sudden personal inspirations but were the result of interacting with others. I often take ideas from different areas of computer science and apply them to new areas. To facilitate cooperation, communication, and the advancement of research, I release all of my implementations as open source so that other researchers can build upon my work. I use GITHUB repository and Research Networks like: ResearchGate, Publons and SCIRESEARCH for much of my day-to-day research, so anyone can find out what I am working on and have access to my latest research.

Research Philosophy

My Research interests are in the area of : Wireless Sensor Networks, Swarm Intelligence, Internet of Things, Wireless Communications, Artificial Intelligence, Blockchain and Smart cum Sustainable Technologies for development. My Research is driven by strong desire to bridge the digital divide and make computing useful to the significant fraction of the world's population to use smart computing for real-time mission critical applications. My Research focusses on:

a. Design and Development of Internet of Things based solutions with fusion of Big Data, Cloud Computing, Embedded Systems and Artificial Intelligence for real-time implementations.
b. Design and development of new computing solutions by integrating Blockchain and Artificial Intelligence to address real-world problems pertaining to global social and economic development.
c. Understanding complex problems pertaining to Wireless Sensor Networks and Healthcare Informatics and addressing via Real Time Implementations using Artificial Intelligence and Swarm Intelligence based optimization techniques.
d. Solving critical problems in Smart and Intelligent Systems like Drones, Metaverse, Augmented Reality, Game Theory and many more.

Computer science, as a field, has largely focused on problems relevant to the developed world. Bridging this digital divide requires us to address several important and challenging computer science research problems whose solutions will ultimately have significant impact on global development. Conventional computing solutions are often inappropriate in these emerging contexts due to various contextual factors including *lack of infrastructure, limited purchasing power, poor connectivity, limited power, language and literacy issues, and lack of local expertise for managing systems*. These unique infrastructure, cost, power and connectivity

constraints create several new research challenges which often require a fundamental rethinking in the way we design computing solutions.

My research philosophy places a strong emphasis on *"IoT based Smart Computing Solutions- Integrating- AI, Blockchain, Sensors, Cloud Computing, Big Data"* solutions for developmental problems.

I use a three-step research process.

- First, performing strong literature review, towards Problem definitions, solutions design, prototype handling and even studying the related prospects towards the ground realities and identify challenging problems.

- Second, Design and implement cost-effective and appropriate computing systems that address the most difficult problems.

- Third, Deployment and Testing of proposed systems in the developing world (with support from funding organizations), rigorously evaluate the system effectiveness and also perform impact evaluation studies where appropriate.

- In the next stage, if possible and feasible, look for organizations to support for funding and even to seed support from Government for seeding into Kickstarter and doing Patents.

In this research statement, I provide a summary of my Dissertation and an overview of my related works in Section 1. Followed by my General discussion on Current and Future aspects in Section 2 and will include a list of my strong Peer-reviewed papers, best in the class and implementations and abstracts. Finally, I conclude my Research statement with Summary.

1 Prior Research

Till date, the core focus of my research is proposing solutions to Wireless Sensor Networks, Studying and Applying Diverse Nature Optimization algorithms towards discrete problems of computer science, making use of AI based techniques for Healthcare Informatics and above all proposing varied solutions of IoT for mission-critical applications.

My empirical research on routing issues and performance issues in Wireless Sensor Networks left with a set of interesting practical challenges. Based on these, I designed efficient Routing Protocols for optimizing WSN using Swarm Intelligence. This section provides a summary of my dissertation and a summary of key-insights for the practical application of my work.

1.1. Dissertation

My thesis is motivated by the complex and challenges surrounding Wireless Sensor Networks with varied problems like Throughput, Packet Deliver Ratio, Energy Efficiency and Routing Overheads. Indeed, the literature is full of routing protocols proposed by several researchers to optimize sensor networks. Technically, some routing protocols were effective in 1-2 parameters but overall quality of WSN network was not improvised to a greater extent. In addition to this, the proposed solutions have limited novelty in terms of working, applying optimization techniques.

Hence, I conducted an interdisciplinary empirical investigation on the nature of Wireless Sensor Networks. Specifically, I focus on: (1) Energy Efficiency (2) Routing Overhead (3) Packet Delivery Ration (4) Throughput. In addition, I also investigated other issues in WSN like Dynamic Nature, Practical issues of implementations.

Initially, looking at varied protocols, I find that there are commonly prevented by technical mitigations. In contracts, some misconfigurations, and parameters limitations is also not improving the state of the quality of Sensor Networks. Furthermore, an additional literature study also indicates that protocols proposed, were not so efficient as compared to standardized protocols.

So, I proposed a Novel Routing Protocol i.e., IEEMARP (Improvised Energy Efficient Multipath ACO based Routing Protocol) which not only improves energy efficiency but also improvises, Packet Delivery Ratio, Throughput and Routing Overhead. And as compared to more than 12+ Protocols, the IEEMARP outperformed existing protocols by 80%.

In summary, I find that the major objectives for the future are: (1) Introduction of Artificial Intelligence and advanced Swarm Intelligence Optimization Techniques for improvising Sensor Networks; (2) Implement IoT solutions for Smart Computing; (3) Extend the work of IoT towards Healthcare Informatics, Drones and even Smart Building for producing outstanding solutions for Industry 4.0, Smart Cities and Sustainable computing.

2. **Current and Future Research**

Extending my previous works on WSN, I have extended my works on advancements towards IoT, Cloud Computing, Big Data and above all proposing solutions to smart computing.
So, I have published several quality research papers and has strong impacts with Strong citations.

I. Current Research

1. DE-SHAP: A Meta-Optimization Framework for Leveraging Differential Evolution for Efficient and Scalable Kernel SHAP Explanations

This paper represents one of my most recent contributions to explainable artificial intelligence, particularly in improving the scalability and efficiency of model interpretability methods. Explainability has become a critical requirement for trustworthy AI systems, especially in healthcare, cybersecurity, finance, autonomous systems, and IoT-enabled decision-making environments. The work proposes DE-SHAP, a meta-optimization framework that integrates Differential Evolution with Kernel SHAP explanations to make feature-attribution analysis more efficient and scalable. Traditional SHAP-based interpretation methods often suffer from high computational cost, especially for large-scale and high-dimensional data. By introducing evolutionary optimization into the explanation process, the proposed framework improves computational efficiency while preserving interpretability quality. This research strongly supports my future agenda on trustworthy AI, explainable cybersecurity, interpretable medical AI, and transparent decision-support systems for mission-critical smart computing applications.

2. **Explainable AI-Driven Intrusion Detection for Securing IoT-Enabled Autonomous Transportation Systems**

This work contributes to the emerging area of explainable AI-based cybersecurity for autonomous transportation systems. IoT-enabled transportation infrastructures, including autonomous vehicles, roadside units, intelligent traffic systems, and connected mobility platforms, generate massive volumes of real-time data and require secure communication for reliable decision-making. However, these environments are highly vulnerable to cyberattacks, data manipulation, and network intrusions. The paper proposes an explainable AI-driven intrusion detection framework to identify malicious behavior while also improving the transparency of security decisions. Unlike black-box intrusion detection models, the proposed approach emphasizes interpretability, allowing security analysts and system operators to understand why a specific activity is classified as malicious. This contribution aligns strongly with my research vision of building secure, intelligent, and trustworthy IoT ecosystems for smart cities, autonomous transportation, cyber-physical systems, and next-generation connected infrastructures.

3. **Medisecure: A Hybrid Approach for Enhancing Multimedia Data Protection in Healthcare**

This recent paper contributes to the important field of secure digital healthcare and multimedia data protection. Modern healthcare systems increasingly depend on the transmission and storage of medical images, CT scans, diagnostic reports, and multimedia patient records. These data are highly sensitive and require strong security mechanisms to preserve patient privacy, data integrity, and regulatory compliance. The proposed Medisecure framework introduces a hybrid protection approach for securing healthcare multimedia data against unauthorized access, tampering, and leakage. The work is especially relevant for telemedicine, cloud-based healthcare storage, medical IoT, hospital information systems, and AI-assisted diagnosis platforms. By focusing on multimedia security in healthcare, this paper advances my broader research direction on privacy-preserving smart healthcare, secure medical IoT, lightweight encryption, and trustworthy cloud-enabled healthcare systems. It also provides a strong foundation for future work involving blockchain, federated learning, and explainable AI in healthcare cybersecurity.

4. **FEMT-FL: A Novel Flexible Energy Management Technique Using Federated Learning for Energy Management in IoT-Based Distributed Green Computing Systems**

This paper advances my research in federated learning, IoT, and green computing by proposing a flexible energy management technique for distributed IoT-based systems. Energy efficiency is a central challenge in large-scale IoT deployments, particularly in smart buildings, smart grids, industrial IoT, and sustainable computing infrastructures. The proposed FEMT-FL framework uses federated learning to support distributed energy management without requiring centralized collection of sensitive device-level data. This improves privacy, scalability, and adaptability while enabling intelligent energy optimization across heterogeneous IoT environments. The work is significant because it connects three important research themes: AI-driven energy management, privacy-preserving distributed learning, and sustainable IoT computing. This contribution directly supports my future research agenda on developing intelligent, autonomous, and environmentally responsible computing systems that can reduce energy consumption, improve operational efficiency, and support global sustainability goals through AI-enabled IoT infrastructures.

5. **SiamIDS: A Novel Cloud-Centric Siamese Bi-LSTM Framework for Interpretable Intrusion Detection in Large-Scale IoT Networks**

This paper proposes SiamIDS, a cloud-centric intrusion detection framework for securing large-scale IoT networks using a Siamese Bi-LSTM architecture. As IoT networks continue to expand across smart cities, healthcare, industrial automation, transportation, and cloud-edge infrastructures, detecting sophisticated cyberattacks in real time has become increasingly challenging. The proposed framework uses deep sequential learning to capture temporal patterns in network traffic and identify abnormal behavior with improved accuracy. The Siamese architecture is particularly useful for learning similarity relationships between normal and malicious traffic patterns, while the cloud-centric design supports scalability for large IoT deployments. The emphasis on interpretability further improves the practical value of the model by supporting transparent cybersecurity decisions. This work strongly aligns with my research direction in AI-based intrusion detection, cloud-enabled IoT security, interpretable deep learning, and cyber-resilient smart infrastructures.

6. **QBD and QBDRL: 3D Bin Packing Novel Approaches for Virtual Machine Placement Using Reinforcement Learning for Energy Optimization in Cloud Computing Infrastructures**

This paper contributes to cloud computing optimization by addressing the critical problem of virtual machine placement and energy management in large-scale data centers. Cloud infrastructures are the backbone of modern digital services, but increasing workloads have created major challenges related to power consumption, resource imbalance, and inefficient server utilization. The paper proposes QBD and QBDRL, novel 3D bin-packing approaches for virtual machine placement, with reinforcement learning used to improve adaptability and energy optimization. Unlike static scheduling techniques, the proposed approach dynamically learns placement strategies according to changing workload conditions. This makes the framework more suitable for real-world cloud environments where workload patterns are unpredictable. This work strengthens my research in AI for cloud resource management, reinforcement learning, green cloud computing, and energy-efficient data-center optimization, and it complements my broader focus on sustainable, intelligent, and scalable computing infrastructures.

7. **Enhancing Security Offloading Performance in NOMA Heterogeneous MEC Networks Using Access Point Selection and Meta-Heuristic Algorithm**

This paper contributes to the area of mobile edge computing, NOMA heterogeneous networks, and secure computation offloading. As next-generation IoT and 6G-enabled applications demand ultra-low latency and high reliability, computation must increasingly be transferred from resource-constrained devices to nearby edge servers. However, offloading in heterogeneous MEC environments introduces challenges related to security, access point selection, resource allocation, interference, and computational efficiency. This work proposes an intelligent approach using access point selection and meta-heuristic optimization to enhance secure offloading performance in NOMA-based MEC networks. The research is particularly relevant for smart transportation, industrial IoT, tactile Internet, remote monitoring, and real-time cyber-physical applications. This contribution fits strongly within my future research direction on edge intelligence, secure offloading, AI-optimized wireless networks, NOMA-MEC systems, and low-latency IoT infrastructures.

8. **SPAKE-DC: A Secure PUF Enabled Authenticated Key Exchange for 5G-Based Drone Communications**

This paper contributes to the rapidly growing research area of secure 5G-enabled drone communications, with a specific focus on authentication and key exchange for cyber-physical aerial networks. Drones are increasingly used in surveillance, disaster management, military operations, smart agriculture, logistics, healthcare delivery, and intelligent transportation. However, their communication channels are highly vulnerable to impersonation, replay attacks, eavesdropping, man-in-the-middle attacks, and physical device compromise. The proposed SPAKE-DC framework introduces a secure PUF-enabled authenticated key exchange mechanism for 5G-based drone communication systems. Physical Unclonable Functions provide hardware-level uniqueness, making the authentication process more resistant to cloning and tampering. This work is significant because it integrates lightweight cryptographic security with next-generation wireless communication, enabling reliable and trustworthy drone operations. It strongly supports my future research agenda in 5G/6G security, UAV networks, IoT-enabled drones, cyber-physical system protection, and lightweight authentication mechanisms for mission-critical environments.

9. **Enabling Secure Image Transmission in Unmanned Aerial Vehicle Using Digital Image Watermarking with H-Grey Optimization**

This paper addresses the important challenge of secure image transmission in unmanned aerial vehicle environments. UAVs are widely deployed for real-time image acquisition in surveillance, border monitoring, disaster response, smart agriculture, traffic management, defense, and remote sensing applications. Since UAVs transmit visual data over wireless channels, the captured images are vulnerable to interception, tampering, unauthorized access, and content manipulation. This work proposes a secure digital image watermarking approach enhanced with H-Grey Optimization, enabling robust protection of UAV-transmitted images. The watermarking mechanism helps preserve ownership, authenticity, and integrity of image data, while the optimization strategy improves robustness and transmission reliability. Published in the high-impact Q1 journal Expert Systems with Applications, this work strengthens my research contributions in AI-based optimization, multimedia security, UAV cybersecurity, secure visual communication, and cyber-physical sensing systems. It also aligns with my broader vision of designing secure and intelligent IoT-enabled aerial platforms for mission-critical smart applications.

10. **Gradient Scaling and Segmented SoftMax Regression Federated Learning: A Novel Methodology for Attack Detection in Industrial Internet of Things Networks**

This paper presents a novel federated learning-based attack detection framework for securing Industrial Internet of Things networks. IIoT systems are central to Industry 4.0 and smart manufacturing, where sensors, actuators, machines, cloud platforms, and edge devices continuously exchange operational data. However, centralized security models are often unsuitable for IIoT because they require sensitive data to be transferred to a central server, increasing privacy risks, latency, and communication overhead. The proposed GDS-SRFFL methodology combines gradient scaling and segmented SoftMax regression within a federated learning environment to detect attacks while preserving distributed data privacy. This approach

enables collaborative learning across industrial nodes without exposing raw data, making it suitable for privacy-aware and scalable industrial cybersecurity. The work is significant because it integrates federated learning, IIoT security, attack detection, and privacy-preserving intelligence. It supports my future research vision of developing secure, autonomous, and trustworthy Industry 4.0 systems powered by AI, edge computing, and decentralized learning.

II. Future Research

My research has focussed on building IoT systems to solve practical real-world problems. I believe, going forward, IoT systems will form the core of three emerging areas in computing. First, questions of sensing, communication, and inference are integral to the promise of digital healthcare. These digital healthcare systems will glean information from wearables, in-body devices, radio signal reflections, and medical records to reduce risk of health emergencies, ensure better treatment procedures, decrease long-term healthcare costs, and generally produce better healthcare outcomes. In addition, the integration of blockchain technology in Healthcare Systems.

Security and Privacy in Smart Environments: The advent of IoT and cyber-physical systems have forced us to change our existing notions of security and privacy. Security and privacy risks are not limited to digital information that is stored online but encompass our physical identities and environments. IoT systems have the capability to sense information about us and our surroundings and can change our physical environments by controlling devices and objects. As a result, there is an urgent need to rethink our security and privacy solutions. I believe the capability of IoT systems to sense our physical environment presents us an opportunity to rethink our security solutions by incorporating the physical information itself into our security approach.

Specifically, the physical information being sensed and the communication channel will form signatures for verifying next-generation IoT devices. I want to build on this intuition to integrate low-level sensing mechanisms with edge architectures, inference mechanisms, and security protocols to design end-to-end security and privacy mechanisms for IoT systems.

Perimeter-based Security: Due to the closed nature of many IoT devices, we often cannot implement defences directly on the device. This poses a challenge to IoT security. I plan to explore defense mechanisms that define the security state and enforce protection of IoT environments from a distance. First, defense mechanisms will utilize outside sensors in the same environment to estimate the security state of an inaccessible IoT device. For example, power sensor readings could reveal the operating characteristics of another connected device, wireless traffic could indicate malicious behavior, and vehicular sensors could reveal anomalies in the control systems. Second, the defense system will have to thwart an adversary without the privilege of running on the IoT device.

In addition to this, making use of Swarm Intelligence techniques for optimizing real world problems in computer science.

Integration of AI and Deep Learning based techniques for IoT, Smart Cities and Buildings.

Summary

In summary, building future IoT will not only benefit users, but also let us revisit the fundamental questions in networking, computing, data science and security. To this end, I will build a group with members of diverse expertise (networking, distributed systems, data science, programming languages, security, Artificial Intelligence etc.). I will actively recruit and mentor both graduate and undergraduate students, particularly from the minority and diversity groups. I will aggressively pursue funding from several funding agencies and industries to propel my high-risk, high-gain" research projects. I will assess my research results along multiple dimensions, including top-conference publications, technology transfer to industries via licensing and patents, commercialization via start-up's, open-source software release, and standardization with industry partners.

Top Research Achievements

- **Published 275+ SCI/SCIE/SSCI Papers in Reputed Peer Reviewed International Journals- (Springer, Elsevier, Sage, Taylor and Francis, Emerald, PLOS One) with High Impact Factor. (Q1/Q2/Q3) Journals**
- **Published 30+ Scopus Papers in International Journals with High Cite Score and Impact Factor**
- **Published 100+ Papers in IEEE Conferences, Springer Conferences, ACM Conferences. (All Web of Science, Scopus Indexed)**
- **Published 60 Edited Book Chapters with Top Quality Books with Springer, CRC Press, IGI-Global, Elsevier, River, AAP Publications, Wiley and many more.**
- **Granted 18 Australian Patents, 44 Indian Patents, 16 German Patents, 4 Japan Patents, 13 UK Patents, 1 US Patent, 3 Indian Copyright and 2 Canadian Copyrights**
- **Google Scholar Citations: 20000+ with H-Index: 72 and I-index: 290; Scopus Citations: 11500+ with H-Index: 55.**
- **More than 10,50,000+ Reads on Research Gate with H-Index: 65**
- **Completed 3 Grant Projects –2 Industry and 1 Grassroot project from Duy Tan University and Undertaking 1 Grassroot and 1 ASEAN Project**
- **Awarded 55 Awards for Research from Reputed Organizations.**
- **Cited among Top 2% Scientists in PLOS One and Stanford University Rankings (2019, 2020, 2021, 2022, 2023, 2024, 2025)**
- **Cited in Research.com (No:2 Rank in Viet Nam) D-Index: 56**
- **Ranked in AD Index (No:1 Duy Tan University and No:1 Viet Nam) Overall in Computer Science.**

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