INSTITUTE OF AERONAUTICAL ENGINEERING

SUMMER RESEARCH INTERNSHIP (SRI) - PROJECT

Information Packet

Academic Year: 2024-25

Appreciate IARE students who are showing interest in the Summer Research Internship (SRI) Project Program at the Institute of Aeronautical Engineering!

SRI team members work as part of a research group of students, research scholars, and faculty members to tackle novel research and design problems around a theme. Students who join SRI teams earn academic credits (RBL / PBL) for participating in design/discovery efforts that assist faculty and students with research and development issues in their areas of expertise.

SRI teams are:

- Collaborative Research – This is an excellent opportunity for students who are committed to research towards social developments and emerging needs for the industry.
- Internship Activity – The project coordinator listed current research areas for offering internships to either a single student or a team size of most two students. The coordinator allotted two mentors based on the research area and facilitated exclusive research laboratories for selected SRI students. This SRI project bridges the gap between academic learning and real-world social applications. It helps for enhancing the professional development
- Long-term - Each student may participate in a project for up to three months (January to March / May to July / September to November).

The primary goal of SRI is to provide a level of consistency, expertise, and diversity of thought in emerging research areas that will allow them to gain hands-on experience in academic or industrial research environments through this internship project.

- Provide students with immersive exposure to empirical research, experimental design, hypothesis formulation, data acquisition, statistical analysis, and technical reporting under expert mentorship.
- Integrate student researchers into ongoing faculty-led research programs, thereby enhancing research throughput.
- Contribute to the development of a vibrant research ecosystem that aligns with the institution’s strategic goals in innovation, interdisciplinary collaboration, and knowledge production.
- Equip students with domain-specific research competencies, fostering critical thinking, problem-solving, and technical communication skills that are essential for advanced academic or industrial careers.
- Promote high-impact research outcomes for social applications, climate change, water management, effective energy usage, agriculture, etc.
- Encourage translational research and innovation with potential for intellectual property generation, prototype development.
- **The research theme of this SRI project also focuses on the challenges presented by the Sustainable Development Goals (SDGs).**

IARE Sustainability Development Goals (SDGs) highlighted with Blue Colour Font	
SDG #1	End poverty in all its forms everywhere
SDG #2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
SDG #3	Ensure healthy lives and promote well-being for all at all ages
SDG #4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
SDG #5	Achieve gender equality and empower all women and girls

SDG #6	Ensure availability and sustainable management of water and sanitation for all
SDG #7	Ensure access to affordable, reliable, sustainable and modern energy for all
SDG #8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
SDG #9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
SDG #10	Reduce inequality within and among countries
SDG #11	Make cities and human settlements inclusive, safe, resilient and sustainable
SDG #12	Ensure sustainable consumption and production patterns
SDG #13	Take urgent action to combat climate change and its impacts
SDG #14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
SDG #15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
SDG #16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
SDG #17	Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

The following research domains are recommended for HIPs-SRI Projects, and selected students should find the research gap and frame the problem statements from any one of the themes below.

1. Cyber Threat Intelligence for Implementation of Secured Systems **(SDG #17)**
2. Ethical Hacking and Penetration Testing for Assessment of Cyber Attacks to Classify Vulnerability **(SDG #15)**
3. Handling Scalability Issues for Big Data Analytics **(SDG #9)**
4. Healthcare Systems with Computing Technologies **(SDG #3)**
5. Climate Data Modelling and Prediction **(SDG #13)**
6. Cognitive Linguistics and NLP **(SDG #4)**
7. Designing Sustainable Intelligent Transportation Systems **(SDG #3)**
8. Robust and Risk-aware Planning for Autonomous Vehicles in Smart Cities **(SDG #15)**
9. Wireless Systems for the Internet of Things **(SDG #9)**
10. Remote Sensing in Agriculture, Crop Yield Prediction & Analytics **(SDG #6)**

In order to participate in SRI, you must formally apply and be accepted by the project coordinator. To proceed, please mail to the project coordinator, Dr. K Rajendra Prasad (dr.rajendraprasad@iare.ac.in), Dean Sponsored Projects & Head of CSE (Data Science & Cyber Security). This will bring up all available open positions tagged as SRI projects. When submitting a project document and an updated résumé, include a statement regarding why you are interested in working with the team to which you are applying.

Please note that participation by the SRI team requires registration for the accompanying research statement from any of the specified domains. More information will be provided to all selected SRI applicants who have been offered a position.

If you have any questions about a particular team, please contact the team's faculty mentor(s).
We encourage you to contemplate this fascinating new opportunity. We look forward to receiving your application submission!

Cyber Threat Intelligence for Implementation of Secured Systems

Dr. K. Rajendra Prasad, Professor & Head, Dept. of CSE (Data Science) – Faculty Mentor

GOALS

To explore the integration of Cyber Threat Intelligence (CTI) into the secure design and implementation of modern information systems. With the increasing frequency and sophistication of cyber threats, traditional security models are insufficient. This project aims to establish a dynamic, intelligence-driven approach to cybersecurity that anticipates and neutralizes threats before they can cause harm. A primary objective is to develop a framework for collecting, analyzing, and applying CTI to enhance threat detection, incident response, and system hardening. This involves leveraging data sources such as IOCs (Indicators of Compromise), TTPs (Tactics, Techniques, and Procedures), and real-time threat feeds to provide contextual awareness across the security infrastructure.

The project also emphasizes automation and scalability, focusing on the deployment of intelligent, self-adaptive systems that respond to emerging threats using artificial intelligence and machine learning. This proactive model supports real-time decision-making, anomaly detection, and continuous system monitoring, significantly reducing response times to threats. Another key goal is to ensure that secured systems comply with industry standards and best practices while being flexible enough to evolve with the threat landscape. The integration of CTI into governance, risk, and compliance (GRC) models ensures long-term sustainability and strategic resilience for both enterprise and critical infrastructure environments. Finally, the project intends to foster collaboration between automated systems and human analysts, ensuring that CTI is machine-readable and actionable for cybersecurity teams. This synergy will enhance the overall cyber defense lifecycle, from threat detection and analysis to mitigation and future threat prevention.

METHODS & TECHNOLOGIES

The project will incorporate STIX/TAXII protocols for threat intelligence sharing, machine learning models for anomaly detection, and SIEM platforms (e.g., Splunk, QRadar) for log aggregation and real-time event analysis. Additionally, threat intelligence platforms (TIPs), endpoint detection and response (EDR), and behavioral analytics tools will be used to simulate and analyze threat scenarios.

MAJORS & AREAS OF INTEREST

The Cyber Threat SRI team needs a diversity of skills:

- Threat Intelligence Analysis – Identify, correlate, and contextualize threat indicators (IOCs, TTPs, threat actors).
- Network and System Security – Design and implementation of secure architectures, firewall rules, and intrusion detection systems.
- Machine Learning in Cybersecurity – Development of predictive models for anomaly detection and threat classification.
- Security Information and Event Management (SIEM) – Real-time monitoring, log analysis, and alerting through platforms like Splunk or QRadar.
- STIX/TAXII Protocols – Structured threat data representation and automated sharing across systems.
- Incident Response & Threat Hunting – Investigation and remediation of security incidents using proactive hunting techniques.
- Scripting & Automation – Automating repetitive tasks in threat detection and response using languages like Python, PowerShell, or Bash.
- Vulnerability and Risk Assessment – Evaluation of system weaknesses and strategic mitigation planning.

MENTOR CONTACT INFORMATION

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PARTNERS & SPONSORS

None

Ethical Hacking and Penetration Testing for Assessment of Cyber Attacks to Classify Vulnerability

Dr. R. Obulakonda Reddy, Professor, Dept. of CSE (Cyber Security) – Faculty Mentor

GOALS

To leverage ethical hacking and penetration testing techniques to identify, assess, and classify vulnerabilities within digital systems. In today's hyperconnected world, cyberattacks are becoming increasingly complex and frequent, making it essential to simulate real-world attack scenarios to understand system weaknesses before malicious actors can exploit them. A core objective is to conduct systematic security assessments using penetration testing methodologies that mimic the tactics and techniques of real attackers. These controlled attacks help uncover vulnerabilities in web applications, network configurations, databases, and access control mechanisms, providing actionable mitigation insights.

The project aims to classify vulnerabilities based on severity, exploitability, and potential impact. By applying standards like the Common Vulnerability Scoring System (CVSS), the research will produce a vulnerability matrix that prioritizes remediation strategies and enhances overall security posture. Another key goal is to promote responsible disclosure and secure development practices. Ethical hacking identifies flaws and supports security-by-design principles by feeding critical feedback into the software development lifecycle (SDLC), ensuring that future systems are inherently more secure.

Finally, this initiative seeks to contribute to cybersecurity awareness and resilience, equipping both technical teams and organizations with the tools and knowledge to proactively defend against cyber threats. The end goal is to build robust, threat-resilient systems through continuous testing, learning, and adaptation.

METHODS & TECHNOLOGIES

The project will use penetration testing tools such as Kali Linux, Metasploit Framework, Burp Suite, and Nmap, alongside vulnerability scanners like Nessus or OpenVAS. Methodologies will follow OWASP Testing Guide and PTES (Penetration Testing Execution Standard) to ensure structured and ethical assessments.

RESEARCH, DESIGN, & TECHNICAL ISSUES

- Inconsistent Testing Environments – Difficulty in replicating real-world infrastructure and attack surfaces for accurate and repeatable vulnerability assessments.
- Tool Limitations & False Positives – Automated tools like Nessus, Nmap, or Metasploit may produce unreliable results, leading to false positives or missed vulnerabilities.
- Vulnerability Classification Complexity – Mapping discovered exploits to severity scores (e.g., CVSS) and attack frameworks (e.g., MITRE ATT&CK) requires deep contextual analysis and precision.
- Legal and Ethical Constraints – Testing boundaries must comply with cybersecurity laws and ethical hacking standards to avoid unauthorized access or data exposure.
- Limited Dataset Access – Lack of access to real-world exploit data and enterprise environments restricts effective research validation and threat simulation accuracy.
- Integration with SDLC – Difficulty in feeding vulnerability assessment outputs into secure development practices for continuous improvement of software security.

MAJORS & AREAS OF INTEREST

This Ethical Hacking and Penetration Testing SRI team needs a diversity of skills:

- Vulnerability Assessment & Exploitation – Identification and classification of system vulnerabilities using CVSS and exploit frameworks.
- Network and Web Application Security – Testing firewalls, servers, APIs, and web interfaces for injection flaws, misconfigurations, and insecure protocols.

- Penetration Testing Methodologies – Applying structured testing standards (e.g., OWASP, PTES) to perform internal and external security assessments.
- Ethical Hacking Tools & Techniques – Proficiency with Kali Linux, Metasploit, Nmap, Burp Suite, Wireshark, and other tools for ethical exploitation.
- Security Reporting & Documentation – Generating detailed vulnerability reports with mitigation recommendations and risk scores.
- Scripting for Security Automation – Using Python, Bash, or PowerShell to automate scanning, payload generation, and exploit chaining.
- Red Teaming & Adversarial Simulation – Simulating advanced persistent threats (APT) to evaluate system resilience and response.
- Secure Coding & SDLC Integration – Feeding vulnerability insights into development workflows to promote secure coding practices.

MENTOR CONTACT INFORMATION

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PARTNERS & SPONSORS

None

Handling Scalability Issues for Big Data Analytics

Dr. Mahammad Rafi D, Professor, Dept. of CSE (Cyber Security) – Faculty Mentor

GOALS

To implement effective strategies for overcoming scalability challenges in big data analytics environments. As data volumes grow exponentially, traditional data processing systems struggle to maintain performance, speed, and accuracy. The project aims to evaluate the root causes of these scalability issues and propose robust architectural and algorithmic solutions. A key focus is on designing scalable data processing pipelines capable of ingesting, storing, and analyzing petabyte-scale datasets with minimal latency. This includes investigating the bottlenecks in data movement, distributed storage, and parallel computation, which are common when dealing with large-scale data systems. Another important goal is to enhance the performance and efficiency of big data platforms such as Apache, Hadoop, Spark, and Flink by optimizing resource utilization, task scheduling, and memory management. Emphasis will be placed on distributed computing models that support horizontal scaling without degradation in processing throughput. The project also aims to address data heterogeneity and infrastructure limitations that arise when scaling across hybrid or multi-cloud environments.

METHODS & TECHNOLOGIES

- Use of distributed computing frameworks like Apache Spark, Hadoop MapReduce, and Apache Flink for large-scale parallel data processing.
- Implementation of NoSQL databases (e.g., Cassandra, MongoDB, HBase) to handle unstructured and semi-structured data at scale.
- Data partitioning and sharding techniques to distribute workload efficiently across nodes.
- Leveraging containerization and orchestration tools (e.g., Docker, Kubernetes) for scalable deployment and resource management.
- Utilization of in-memory computing for performance optimization (e.g., Apache Ignite, Spark in-memory RDDs).
- Integration of stream processing systems (e.g., Kafka Streams, Apache Storm) for handling real-time analytics workloads.

RESEARCH, DESIGN, & TECHNICAL ISSUES

This SRI team will focus on Scalability issues that often arise due to data skew, network congestion, and resource contention in distributed environments. Designing fault-tolerant, load-balanced architectures while maintaining real-time performance is technically challenging. Additionally, ensuring cost-efficiency and performance consistency in elastic and cloud-native infrastructures presents significant design complexity.

MAJORS & AREAS OF INTEREST

The following majors or areas of interest are identified in this theme of research work:

- Distributed Systems Architecture – Design of horizontally scalable, fault-tolerant data analytics systems.
- Big Data Frameworks – Proficiency in Hadoop, Spark, Flink, and other scalable platforms.
- Data Storage & Retrieval Optimization – Techniques in partitioning, indexing, and sharding large datasets.
- Real-time Stream Processing – Handling time-sensitive analytics through tools like Kafka, Storm, and Flink.
- Cloud & Container Orchestration – Deployment and scaling using AWS, Azure, Kubernetes, and Docker.
- In-Memory & Parallel Computing – Speeding up analytics via Spark RDDs, Ignite, or Dask.
- Performance Monitoring & Tuning – Profiling resource usage, identifying bottlenecks, and optimizing workloads.
- Data Engineering & ETL Pipelines – Designing scalable data workflows for ingestion, transformation, and analysis.

MENTOR CONTACT INFORMATION

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PARTNERS & SPONSORS

None

Healthcare Systems with Computing Technologies

Dr. P Ramadevi, Associate Professor, Dept. of CSE (Cyber Security) – Faculty Mentor

GOALS

The primary goal of this project is to explore the integration of advanced computing technologies into healthcare systems to improve diagnostics, patient management, data handling, and clinical decision-making. The healthcare industry is undergoing a digital transformation, and this project aims to leverage computational tools to enhance operational efficiency and patient outcomes. A significant objective is to design and develop intelligent healthcare infrastructures using technologies like Artificial Intelligence (AI), Internet of Things (IoT), and Electronic Health Records (EHRs). These systems aim to support early disease detection, personalized treatment plans, and automation of routine clinical workflows.

The project also focuses on enabling real-time data acquisition and analysis from wearable devices, remote monitoring tools, and connected medical sensors. This continuous data stream can provide actionable insights for healthcare professionals and support preventive care strategies. Additionally, ensuring data privacy, security, and interoperability across diverse healthcare platforms is a core goal. Implementing robust encryption, compliance with standards like HIPAA, and facilitating seamless communication between heterogeneous systems are key to building trust and efficiency in digital healthcare ecosystems. Lastly, the initiative seeks to empower healthcare stakeholders—clinicians, patients, and administrators—through user-centric design and accessible interfaces. The goal is to create intuitive systems that improve usability while ensuring scalability and resilience under growing demand.

METHODS & TECHNOLOGIES

- Artificial Intelligence (AI) & Machine Learning (ML) for Clinical Decision Support
- Advanced algorithms are employed for disease diagnosis, patient risk stratification, and treatment recommendation. Techniques such as deep learning (CNNs, RNNs) are used in medical image analysis (e.g., MRI, CT scans), while NLP models support analysis of unstructured clinical notes.
- Internet of Medical Things (IoMT) & Smart Sensors
- Integration of wearable health devices (e.g., ECG monitors, glucose sensors, smartwatches) facilitates continuous patient monitoring. Sensor data is transmitted via IoT protocols (e.g., MQTT, CoAP) to centralized systems for real-time analytics and alerts.
- Cloud-Based Health Data Management
- Cloud services like AWS HealthLake, Microsoft Azure for Health, and Google Cloud Healthcare API offer scalable infrastructure for storing and processing large volumes of health data. These platforms support FHIR/HL7 standards and enable secure multi-region deployments with built-in compliance.
- Electronic Health Records (EHR) & Interoperability Standards
- Development of interoperable EHR systems using Fast Healthcare Interoperability Resources (FHIR), HL7, and DICOM standards allows seamless exchange of patient records across hospitals, labs, and insurance providers. These systems support CRUD operations on structured clinical data using RESTful APIs.
- Blockchain for Secure Medical Transactions
- Blockchain networks (e.g., Hyperledger Fabric, Ethereum) are used for storing immutable medical records and managing consent in a decentralized manner. Smart contracts can automate access control, ensuring auditability and traceability of medical data access.
- Telemedicine and Remote Diagnostic Platforms
- Implementation of real-time communication protocols (e.g., WebRTC, SIP) allows audio/video consultations, remote diagnostics, and virtual monitoring. Integrated with AI-based triaging systems, these platforms improve healthcare accessibility and reduce clinical burden.

RESEARCH, DESIGN, & TECHNICAL ISSUES

In general, SRI team members will be involved in healthcare systems face challenges in handling large-scale heterogeneous data from various sources, ensuring compliance with data privacy laws, and integrating legacy systems with modern computing technologies. Designing systems that balance accuracy, security, and usability is technically and ethically demanding.

MAJORS & AREAS OF INTEREST

These areas are listed below in this theme of work:

- Health Informatics & EHR Systems – Development and management of interoperable digital health records.
- AI in Healthcare – Application of machine learning for diagnosis, predictive analytics, and treatment optimization.
- IoT & Biomedical Sensors – Designing smart health monitoring systems using wearable technologies.
- Data Privacy & Security – Implementation of HIPAA-compliant, encrypted healthcare data solutions.
- Telemedicine & Virtual Care Platforms – Building scalable solutions for remote patient engagement.
- Cloud Computing for Healthcare – Use of cloud infrastructures for scalable health data storage and computation.
- Human-Centered System Design – Creating accessible and user-friendly interfaces for clinicians and patients.
- Blockchain in Health Tech – Applying decentralized systems to maintain secure medical records and audit trails.

MENTOR CONTACT INFORMATION

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PARTNERS & SPONSORS

None

Climate Data Modelling and Prediction

Dr. Sajja Suneel, Professor, Dept. of CSE (Data Science) – Faculty Mentor

GOALS

The primary goal of this project is to develop accurate and scalable models for analyzing and predicting climate patterns using historical and real-time environmental data. With the increasing impact of climate change on global ecosystems, societies, and economies, it is critical to build systems that provide timely insights for climate forecasting, disaster preparedness, and environmental planning.

A major objective is to collect, clean, and preprocess large-scale climate datasets, including temperature, precipitation, humidity, CO_2 emissions, oceanographic data, and satellite imagery. These data are often heterogeneous and unstructured, requiring advanced data engineering techniques to make them usable for predictive modeling. Another goal is to leverage statistical, machine learning (ML), and deep learning methods to build climate prediction models capable of short-term and long-term forecasting. Models like ARIMA, LSTM networks, and ensemble learning methods will be investigated to capture seasonal trends, anomalies, and extreme weather event patterns. In addition, the project aims to address spatial-temporal challenges in climate modeling by integrating geospatial data using GIS systems and remote sensing technologies. The goal is to generate high-resolution, region-specific climate forecasts that can support policymakers and urban planners in implementing climate adaptation strategies.

Lastly, there is an emphasis on developing visualization tools and dashboards to interpret and communicate predictive results effectively to non-technical stakeholders. This involves creating interactive interfaces and reports that help convert model outputs into actionable insights.

METHODS & TECHNOLOGIES

- Time Series Forecasting Models – Utilization of ARIMA, Prophet, and LSTM for short- and long-term climate trend prediction.
- Geospatial Data Integration – Use of GIS tools (e.g., QGIS, ArcGIS) and satellite data (e.g., NASA MODIS, Copernicus) for spatial modeling.
- Machine Learning Frameworks – Application of Random Forests, XGBoost, and CNNs for feature extraction and classification of climate phenomena.
- Big Data Platforms – Implementation of Apache Spark, Hadoop, and cloud storage (AWS S3, Google Big Query) for handling massive climate datasets.
- Climate Data APIs – Integration of APIs like NOAA, ECMWF, and Open Weather Map for real-time data streaming and analysis.
- Visualization Tools – Deployment of dashboards using Tableau, Power BI, or D3.js to present model results and trend analytics.

RESEARCH, DESIGN, & TECHNICAL ISSUES

Climate modeling faces challenges such as data sparsity, model overfitting, and computational inefficiency, especially when handling high-dimensional spatiotemporal data. Ensuring model generalizability across geographies and maintaining data accuracy in the face of climate anomalies are major technical design hurdles.

MAJORS & AREAS OF INTEREST

The faculty mentors and research coordinator for the team are looking for SRI team members interested in:

- Climate Informatics & Environmental Modeling – Applying computational methods to model and understand climate dynamics.
- Time Series Analysis & Forecasting – Developing predictive models for environmental variables over time.
- Remote Sensing & Geospatial Analytics – Analyzing satellite imagery and spatial datasets for regional climate assessments.

- Machine Learning for Climate Science – Training models to classify, cluster, and predict climate-related patterns and events.
- Data Engineering & Preprocessing – Handling heterogeneous data sources including missing values, outliers, and noise in climate data.
- Cloud Computing & Big Data Analytics – Processing massive environmental datasets using scalable cloud-native architectures.
- Data Visualization & Scientific Communication – Designing interactive dashboards to communicate complex climate insights clearly.
- Climate Risk Assessment & Simulation – Modeling climate scenarios and their socio-economic impact through simulations and risk metrics.

MENTOR CONTACT INFORMATION

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PARTNERS & SPONSORS

None

Cognitive Linguistics and NLP

Dr. M V Krishna Rao, Professor, Dept. of CSE(Data Science) – Faculty Mentor

GOALS

To bridge the gap between human cognitive processes and computational language models by integrating principles from cognitive linguistics into natural language processing (NLP). Cognitive linguistics emphasizes how meaning is constructed and understood in the human mind, providing a rich foundation for improving how machines interpret and generate language.

This initiative aims to enhance the semantic and contextual understanding in NLP models by incorporating cognitive theories of metaphor, embodiment, and conceptual framing. Traditional NLP models often focus on syntactic and statistical features, but cognitive linguistics introduces deeper semantic patterns that more accurately reflect human language use.

Another critical objective is to explore cognitively-informed models for tasks such as sentiment analysis, machine translation, and discourse modeling. These models aim to go beyond word-level understanding, capturing pragmatic meaning, speaker intention, and conceptual mappings that are central to human communication.

The project also investigates the development of multilingual and cross-cultural NLP systems using cognitive frameworks that account for language variation and conceptual differences. The goal is to design models that are more adaptable and aligned with human reasoning across linguistic and cultural boundaries.

Finally, the project will focus on interpretable and explainable NLP systems that mirror human-like reasoning, making AI more transparent and understandable. Such systems will benefit fields such as education, digital humanities, and assistive technologies by providing linguistically grounded, human-centric computational tools.

METHODS & TECHNOLOGIES

- Transformer-based models (e.g., BERT, GPT, RoBERTa) with cognitive embeddings for improved semantic comprehension.
- Conceptual metaphor analysis tools for integrating figurative language processing into NLP pipelines.
- Frame semantics and construction grammar frameworks applied to language understanding tasks.
- Multilingual language models (e.g., XLM-R, mBERT) for cross-linguistic cognitive comparison and NLP tasks.
- Discourse and narrative modeling using neural architectures informed by cognitive discourse structures.
- NLP libraries and platforms such as spaCy, NLTK, HuggingFace Transformers, and AllenNLP for implementation.

RESEARCH, DESIGN, & TECHNICAL ISSUES

Integrating cognitive linguistic theory into NLP models involves complex representations of abstract semantic structures, which are often not directly observable in raw data. Designing systems that model metaphor, conceptual blending, and mental schemas remains a key technical challenge, requiring computational innovation and linguistic insight.

MAJORS & AREAS OF INTEREST

The following majors and/or have a background and interest in this theme of the work.

- Computational Semantics & Syntax – Understanding and implementing language models that capture meaning and grammatical structure.

- Cognitive Modeling of Language – Applying theories of conceptual metaphor, mental spaces, and embodiment in NLP.
- Natural Language Understanding (NLU) – Building systems that interpret sentiment, intent, and context using cognitive principles.
- Discourse & Pragmatics Analysis – Developing models that understand coherence, deixis, and speaker intent in dialogue.
- Multilingual & Cross-Cultural NLP – Adapting language technologies across different linguistic and cultural frameworks.
- Explainable & Interpretable AI – Designing transparent models that reflect human-like reasoning in language tasks.
- Neural Language Modeling – Training deep learning models (e.g., RNNs, Transformers) to simulate human cognitive language processing.
- Corpus Linguistics & Annotation – Constructing and analyzing annotated linguistic datasets with cognitive and functional tags.

MENTOR CONTACT INFORMATION

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PARTNERS & SPONSORS

None

Designing Sustainable Intelligent Transportation Systems

Dr. G.Ganapthi Rao, Associate Professor, Dept. of CSE (Data Science) – Faculty Mentor

GOALS

To develop intelligent transportation systems (ITS) that are environmentally sustainable, energy-efficient, and adaptable to urban growth. These systems leverage smart technologies to enhance transportation networks' efficiency, safety, and ecological footprint.

A key objective is incorporating real-time traffic data, predictive analytics, and dynamic routing algorithms to reduce congestion, lower vehicle emissions, and optimize mobility. By analyzing vehicle flow patterns and commuter behavior, the system aims to manage transportation resources intelligently while minimizing environmental impact. Another goal is the integration of renewable energy sources, electric vehicles (EVs), and smart charging infrastructure within transportation ecosystems. The project seeks to design urban mobility platforms that are compatible with low-emission zones, carbon neutrality goals, and green urban policies.

Additionally, this initiative emphasizes multi-modal transportation design, incorporating public transport, cycling, and pedestrian pathways into a connected smart grid. Advanced IoT and communication protocols (like V2X) will be implemented to ensure system-wide interoperability and user responsiveness. Finally, the project aspires to deliver data-driven policy recommendations and urban planning tools, enabling cities to future-proof their infrastructure through AI, GIS, and simulation-based approaches. The overarching goal is a transportation ecosystem that is both intelligent and efficient, and sustainable in the long term.

METHODS & TECHNOLOGIES

Team members interested in Intelligent Transportation Systems impact modeling for transportation systems will utilize a number of methods and technologies, including literature research, expert interviews, data analytics, and computer programming (R, Python, or more complex atmospheric models) and will build domain knowledge in transportation engineering. Team members interested in eco-driving will utilize a number of methods and technologies, including basic hardware skills (e.g., assembling sensors on a robot car), ROS programming, Autoware software platform, motion planning and control for autonomous vehicles, and computer programming (Python).

- Artificial Intelligence and Machine Learning for traffic prediction, route optimization, and incident detection.
- IoT and Sensor Networks for real-time vehicle, pedestrian, and environmental monitoring.
- V2X (Vehicle-to-Everything) Communication protocols for smart traffic coordination and vehicle autonomy.
- GIS and Spatial Analytics for route planning, land use modeling, and infrastructure deployment.
- Electric Vehicle Integration with smart grid and charging infrastructure for sustainable energy usage.
- Simulation Platforms such as SUMO, MATSim, or AnyLogic for modeling traffic flow and system performance.

RESEARCH, DESIGN, & TECHNICAL ISSUES

Designing sustainable ITS involves balancing energy efficiency with system complexity, ensuring interoperability among heterogeneous components, and maintaining scalability under urban expansion. Technical barriers include real-time data processing, cybersecurity in V2X communication, and integrating legacy systems with emerging tech.

MAJORS & AREAS OF INTEREST

This theme is interested in a variety of majors, including but not limited to:

- Smart Mobility & Urban Informatics – Designing intelligent mobility frameworks for urban environments.

- Real-Time Data Analytics & Traffic Modeling – Processing and analyzing transportation data for dynamic decision-making.
- IoT & Sensor Integration – Developing embedded systems for environment-aware, interconnected transport networks.
- GIS & Spatial Computing – Applying location intelligence for urban transport planning and analysis.
- Machine Learning for Transportation Systems – Training predictive models for congestion, demand forecasting, and vehicle dispatch.
- V2X & Autonomous Vehicle Technologies – Enabling communication between vehicles, infrastructure, and control centers.
- Green Computing & Energy Optimization – Implementing sustainable design principles and energy-aware routing algorithms.
- Simulation & Digital Twin Technology – Using virtual environments to test and optimize intelligent transportation strategies.

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PARTNERS & SPONSORS

None

Robust and Risk-aware Planning for Autonomous Vehicles in Smart Cities

Dr. S.Sreekanth, Associate Professor, Dept. of CSE (Data Science) – Faculty Mentor

GOALS

The main goal of this project is to develop robust and risk-sensitive planning algorithms for autonomous vehicles (AVs) that can operate reliably within the dynamic and complex environments of smart cities. It aims to bridge the gap between theoretical planning models and real-world deployment by incorporating risk awareness, safety margins, and uncertainty handling into AV decision-making frameworks.

The project seeks to enable AVs to make safe and context-aware navigational decisions in uncertain and partially observable environments, including unpredictable pedestrian behavior, variable weather, or sensor noise. By integrating probabilistic modeling and real-time risk assessment, AVs can better anticipate edge cases and maintain operational safety even under unforeseen conditions. Another central goal is to ensure urban-scale integration of AVs into smart mobility systems, harmonizing with traffic infrastructure, other vehicles (including human-driven), and IoT-enabled roadside systems. This requires advanced coordination strategies and adherence to urban traffic policies, with considerations for congestion, energy efficiency, and environmental impact.

Additionally, the research emphasizes the scalability and generalizability of the planning system. The idea is to deploy AVs that can adapt to varying city infrastructures across regions, with transferable intelligence based on machine learning and continual learning from real-world data. Ultimately, the system aims to contribute to a safer, more efficient, and sustainable urban transportation system—minimizing accidents, reducing delays, and supporting the broader smart city vision through interoperable, risk-aware autonomy.

METHODS & TECHNOLOGIES

- Probabilistic motion planning algorithms such as POMDPs, RRT*, and risk-aware A* are used for safe and optimal pathfinding.
- Bayesian Inference & Risk Assessment Models to quantify uncertainty and assess collision likelihood in real-time.
- Sensor Fusion & Perception Systems (e.g., LiDAR, RADAR, cameras) for robust situational awareness in complex environments.
- Vehicle-to-Everything (V2X) Communication for interaction with smart infrastructure, traffic signals, and other AVs.
- Reinforcement Learning & Deep Learning for adaptive policy learning in dynamic urban traffic scenarios.
- Simulation Platforms like CARLA, SUMO, and AirSim for testing risk-aware planning in diverse smart city scenarios.

RESEARCH, DESIGN, & TECHNICAL ISSUES

Risk-aware AV planning must address challenges such as real-time uncertainty modeling, failure tolerance in dynamic environments, and ethical decision-making under risk trade-offs. Designing AVs to operate safely in dense urban settings with incomplete information and ensuring system-level integration with smart infrastructure are key technical hurdles.

MAJORS & AREAS OF INTEREST

The following are identified the works in the following majors and/or with a background and interest in the areas listed below:

- Autonomous Systems & Robotics – Designing control and planning modules for AV navigation and decision-making.
- Probabilistic & Risk-sensitive Planning – Implementing stochastic models that can handle uncertainty in real-time environments.
- Sensor Fusion & Environmental Perception – Integrating multi-modal sensor data for object detection and semantic scene understanding.
- Reinforcement Learning & Adaptive Control – Building intelligent agents that learn optimal driving strategies through feedback.
- Smart City Integration & V2X Communication – Developing AVs that interact with traffic systems, pedestrians, and infrastructure.
- Cyber-Physical Systems & Real-time Embedded Computing – Ensuring safety, latency, and reliability in on-vehicle computations.
- Ethical AI & Human-in-the-loop Systems – Addressing decision-making in high-risk scenarios with ethical and social implications.
- Simulation & Virtual Testing Environments – Using realistic simulators for training, testing, and validating AV behaviors at scale.

MENTOR CONTACT INFORMATION

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PARTNERS & SPONSORS

None

Wireless Systems for the Internet of Things

Dr. K.Rajendra Prasad, Professor & Head, Dept. of CSE (Data Science) – Faculty Mentor

GOALS

To design, optimize, and implement advanced wireless systems tailored for the connectivity demands of the Internet of Things (IoT). As IoT devices proliferate across healthcare, smart homes, agriculture, and industry sectors, the underlying wireless infrastructure must be scalable, low-power, and highly reliable. A major objective is to investigate and develop energy-efficient communication protocols and architectures that support massive IoT device deployments. These protocols must ensure low latency, long battery life, and minimal packet loss, particularly in resource-constrained environments.

The project also focuses on enabling interoperability across heterogeneous wireless technologies, such as Wi-Fi, Bluetooth Low Energy (BLE), Zigbee, LoRaWAN, NB-IoT, and 5G. Seamless integration among these technologies is crucial for creating cohesive IoT ecosystems with robust end-to-end connectivity.

Another essential goal is to enhance security and resilience in wireless IoT communication, especially against attacks such as eavesdropping, jamming, spoofing, and man-in-the-middle attacks. Lightweight encryption schemes, secure key distribution, and anomaly detection systems will be explored. Lastly, the initiative aims to develop intelligent network management techniques for dynamic spectrum allocation, fault detection, device discovery, and network optimization using AI and machine learning. These methods are vital for ensuring adaptive and self-healing IoT communication environments.

METHODS & TECHNOLOGIES

- Low-power Wide Area Networks (LPWANs) such as LoRaWAN, Sigfox, and NB-IoT for long-range, energy-efficient IoT communication.
- Short-range protocols like BLE, Zigbee, and Thread for indoor mesh networks and proximity-based communication.
- Edge Computing and Fog Networking to minimize latency and reduce dependency on cloud infrastructures.
- 5G & Wi-Fi 6 Integration for ultra-reliable, high-throughput, low-latency IoT services in smart cities and industries.
- AI-driven Network Management using machine learning models for traffic prediction, congestion control, and energy optimization.
- Embedded and Real-time OS Platforms such as TinyOS, RIOT, or FreeRTOS for IoT node software development.

RESEARCH, DESIGN, & TECHNICAL ISSUES

This SRI will address the following challenges:

Development of a Designing wireless systems for IoT involves challenges such as spectrum scarcity, energy constraints, interoperability, and scalability in dense deployments. Additional issues include maintaining QoS (Quality of Service) under mobility and addressing security vulnerabilities in lightweight and constrained environments.

MAJORS & AREAS OF INTEREST

This theme is identified in the following majors and/or with a background and interest in the areas listed below:

- Wireless Communication Protocols for IoT – Understanding and implementing Zigbee, BLE, LoRa, NB-IoT, and 6LoWPAN.
- Network Architecture & Topology Design – Configuring mesh, star, and hybrid wireless network infrastructures for scalable deployments.
- Embedded Systems Programming – Developing firmware and real-time applications for constrained IoT devices.

- Security in Wireless IoT Networks – Designing lightweight cryptographic algorithms and intrusion detection systems.
- Machine Learning for Network Optimization – Applying ML for smart scheduling, device clustering, and anomaly detection.
- Edge & Fog Computing Integration – Offloading data processing from the cloud to edge devices for faster response and reduced bandwidth use.
- Sensor Integration & Wireless Interfaces – Interfacing various sensors using SPI, I2C, UART over wireless protocols.
- 5G and Next-gen Connectivity for IoT – Leveraging new-generation networks for industrial and smart city applications.

MENTOR CONTACT INFORMATION

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PARTNERS & SPONSORS

None

Remote Sensing in Agriculture, Crop Yield Prediction & Analytics

Dr. K. Rajendra Prasad, Professor & Head, Dept. of CSE (Data Science) – Faculty Mentor

GOALS

The primary goal of this project is to leverage remote sensing technologies and data analytics to enhance agricultural decision-making, particularly focusing on crop monitoring, yield forecasting, and resource optimization. The project aims to improve precision agriculture practices for better crop productivity and sustainability by integrating satellite imagery, drone data, and multispectral sensors.

A key objective is to develop predictive models for crop yield estimation using historical data, vegetation indices (like NDVI, EVI), and environmental parameters. These models will help forecast yields in different regions under varying climatic and soil conditions, supporting both farmers and policymakers with data-driven insights.

This project also aims to support early detection of crop stress, disease, and pest outbreaks through high-resolution imagery and pattern recognition techniques. Real-time monitoring enables proactive management strategies, reducing the need for excessive chemical usage and minimizing crop loss. Another important goal is the development of analytics dashboards and visualization tools to deliver insights to end-users. This includes web-based platforms or mobile applications that provide farmers and agronomists with actionable intelligence based on remote sensing and geospatial data. Finally, the initiative will contribute to sustainable agricultural practices and food security, by optimizing input usage (water, fertilizer, pesticides), minimizing environmental impact, and helping adapt to climate change through resilient crop planning and risk management strategies.

METHODS & TECHNOLOGIES

- Satellite Remote Sensing & UAV-based Data Acquisition for high-resolution multispectral and thermal imagery.
- Vegetation Index Calculation such as NDVI, SAVI, and EVI to assess crop health and growth stages.
- Geographic Information Systems (GIS) for spatial data processing, mapping, and land use classification.
- Machine Learning Algorithms (e.g., Random Forest, SVM, Deep Learning) for predictive yield modeling and anomaly detection.
- Time Series Analysis & Forecasting Models using weather and sensor data for yield trend predictions.
- Cloud-based Platforms like Google Earth Engine and AWS for scalable image processing and data analytics.

RESEARCH, DESIGN, & TECHNICAL ISSUES

This domain presents challenges such as variability in satellite data resolution and cloud cover, data integration from multiple heterogeneous sources, and the need for region-specific model calibration. Additionally, real-time processing and accessibility of remote sensing data for small-scale farmers remains a design and implementation hurdle.

MAJORS & AREAS OF INTEREST

- Religion and/or Peace Studies
- Remote Sensing & Image Processing – Working with satellite and UAV imagery for agricultural assessment.
- Geospatial Data Analytics & GIS – Mapping and spatial modeling using tools like QGIS, ArcGIS, or GDAL.
- Machine Learning for Yield Prediction – Building predictive models using agronomic, climatic, and spectral data.

- Precision Agriculture & IoT Integration – Deploying sensor networks and smart devices for field-level monitoring.
- Data Visualization & Dashboards – Developing analytics interfaces for farmers and decision-makers.
- Crop Health Monitoring & Stress Detection – Using thermal and spectral indices to detect issues early.
- Cloud Computing for Agricultural Big Data – Using platforms like GEE and AWS Lambda for scalable processing.
- Climate-smart Agriculture Planning – Integrating remote sensing with weather models for adaptive farming strategies.

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PARTNERS & SPONSORS

None