IARE
INSTITUTE OF
AERONAUTICAL ENGINEERING

HIGH IMPACT PRACTICES (HIPS)
CORNERSTONE PROJECTS: DESIGN ENGINEERING
INFORMATION PACKET

2025 - 2026

INSTITUTE OF AERONAUTICAL ENGINEERING

25 YEARS 2000 2025

I appreciate IARE students who are showing interest in **Next-Gen Design Engineering with Artificial Intelligence (NextDEAI)** Project Program at the Institute of Aeronautical Engineering.

The **NextDEAI** Project 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. The **NextDEAI** initiative brings together students, research scholars, and faculty to collaboratively explore and solve challenges in intelligent product design and engineering innovation using AI/ML technologies. This program aims to bridge the gap between design theory, intelligent computation, and sustainable innovation, enabling smarter and faster design decisions throughout the product lifecycle.

The goal is to integrate AI throughout the Design Engineering Lifecycle, from concept development to simulation, optimization, prototyping, and manufacturing, enhancing innovation, precision, and sustainability in engineering design. Core Goals of Next-Gen Design Engineering with Artificial Intelligence (NextDEAI) are:

- **Undergraduate Research in AI & Design Engineering**
  Engaging students in hands-on, AI-driven design research projects focused on intelligent CAD modeling, generative design, human-centered innovation, and more.

- **Capstone Design Projects**
  Final-year projects where students apply AI techniques to create innovative, functional, and user-centered designs using tools like generative design, topology optimization, and digital twins.

- **Internships & Industry Engagement**
  Providing students with real-world exposure through internships in industries adopting AI in design, such as automotive, aerospace, biomedical, and product development sectors.

- **Service Learning / Community Projects**
  Designing AI-supported solutions for societal needs—such as assistive devices, sustainable packaging, or low-cost home appliances—impacting local communities.

- **Global Learning & Exchange**
  Encouraging global collaboration through international hackathons, student exchanges, and joint projects involving design, AI ethics, and sustainable engineering.

- **Enhanced Problem Solving and Innovation**
  Empowering students to think creatively and use AI tools like reinforcement learning, computer vision, and neural networks to solve complex design problems.

- **Real-world Readiness with Ethical and Societal Understanding**
  Ensuring students create AI-driven designs that are safe, inclusive, environmentally responsible, and aligned with human values and the Sustainable Development Goals (SDGs).

The research theme of this AI based NextDEAI projects also focuses on the challenges presented by the Sustainable Development Goals (SDGs).

Sustainability Development Goals (SDGs) for the Dept. of ME, IARE	
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 #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

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

1. Generative Design and AI-Based CAD Modelling for Product Innovation ***(SDG #9, SDG #12)***
2. AI-Based Generative Design for Lightweight Structural Components ***(SDG #9, SDG #12, SDG #13)***
3. Design Automation using NLP and Computer Vision for Drawing Interpretation ***(SDG #4, SDG #8, SDG #19)***
4. Sustainable Product Design using AI and Lifecycle Assessment (LCA) ***(SDG #6, SDG #9, SDG #12, SDG #13)***
5. AI-Based Design for Additive Manufacturing (DfAM) and Topology Optimization ***(SDG #9)***
6. Deep Learning for Adaptive Mesh Refinement in Structural FEM Simulation ***(SDG #9, SDG #12)***
7. AI-Supported Prosthetic Limb Design for Custom Fit and Functionality ***(SDG #3, SDG #9, SDG #10)***
8. AI-Enabled Virtual Prototyping and Rapid Design Validation ***(SDG #9, SDG #12)***
9. Autonomous Vehicle Component Design Optimization using AI ***(SDG #9, SDG #11, SDG #12, SDG #13)***
10. AI-Based Design of Impact-Absorbing Structures for Crash Safety ***(SDG #3, SDG #9, SDG #11)***

In order to participate in **NextDEAI** Projects, you must formally apply and be accepted by the project coordinator. To proceed, please mail to the project coordinator, Dr. GVR Sehsagiri Rao, Professor, Mechanical Engineering, Email Id: gvr.seshagirirao@iare.ac.in. This will bring up all available open positions tagged as **NextDEAI** 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 **NextDEAI** project team requires registration for the accompanying research statement from any of the specified domains. More information will be provided to all selected **NextDEAI** project 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.

Generative Design and AI-Based CAD Modelling for Product Innovation

Dr. GVR Seshagiri Rao, Professor, Dept. of ME - Faculty Mentor

GOALS

This project focuses on integrating Generative Design and AI-Driven Computer-Aided Design (CAD) to revolutionize the product development process by automating and optimizing early-stage design. Traditional design workflows often depend on the iterative manual refinement of geometry, which can be time-consuming, subjective, and suboptimal in performance. Generative Design, empowered by AI and optimization algorithms, explores thousands of design permutations based on performance goals, material constraints, manufacturing processes, and aesthetics—thus enabling designers and engineers to make better-informed, creative, and sustainable decisions.

The primary objective is to build an intelligent design system that combines AI, topology optimization, and CAD modeling to accelerate innovation and reduce development costs. This includes creating lightweight structures, functionally optimized parts, and customized products across industries such as aerospace, automotive, biomedical, and consumer goods. AI techniques such as reinforcement learning, deep generative models, and design space exploration algorithms are leveraged to automate design generation and validation within modern CAD platforms.

Key Goals:

- Automate the design exploration process to enhance creativity and innovation.
- Use AI to generate high-performance, manufacturable product geometries.
- Integrate generative algorithms with CAD software for real-time model updates.
- Support sustainable design through material optimization and topology refinement.
- Enable rapid prototyping, customization, and iterative validation cycles.

METHODS & TECHNOLOGIES

The project uses Generative Design principles powered by AI/ML models and integrated with parametric and feature-based CAD systems. The workflow leverages geometry processing, optimization solvers, and deep learning models for shape generation and performance prediction.

Methods (Process & Approach):

- **Design Objective & Constraint Definition**
  Define performance goals: weight, stress limits, thermal resistance, etc. Set geometric constraints: boundary conditions, load paths, material type, and manufacturing method.
- **AI-Powered Generative Design Algorithms**
  Use topology optimization and evolutionary algorithms to create design variants. Apply GANs (Generative Adversarial Networks) or VAEs (Variational Autoencoders) for geometry synthesis. Employ reinforcement learning for adaptive geometry iteration.
- **Simulation and Validation**
  Use Finite Element Analysis (FEA) to simulate mechanical behavior. Evaluate fitness using strength-to-weight ratio, compliance, thermal performance, etc.
- **CAD Model Generation and Integration**
  Convert optimal solutions into editable CAD models using AI-based feature recognition. Integrate with platforms like Autodesk Fusion 360, SolidWorks, or Siemens NX.
- **User Feedback Loop & Iterative Refinement**
  Allow designers to guide AI with preferences and constraints. Refine models based on user validation and functional testing.

Technologies Used:

- **AI/ML Libraries:** TensorFlow, PyTorch, Scikit-learn, DEAP (for evolutionary algorithms)
- **Optimization Tools:** OptiStruct, ANSYS, COMSOL Multiphysics
- **CAD Software:** Autodesk Fusion 360, SolidWorks API, Rhino/Grasshopper
- **Programming Languages:** Python, C++, MATLAB (for simulation integration)

MAJORS & AREAS OF INTEREST

This Cornerstone Project (CoP) is ideal for students from Mechanical Engineering, Design Engineering, Computer Science, and Industrial Design with interests in AI-driven product development and next-gen CAD workflows. Key areas of focus include:

- **Generative Design & Topology Optimization** – Exploring lightweight, high-performance structures by using AI-powered optimization techniques to reduce material usage and enhance functionality.
- **AI for Parametric & Algorithmic Design** – Developing AI/ML models (e.g., deep generative models, reinforcement learning) to automate parametric geometry generation and shape exploration.
- **AI-Integrated CAD Modelling** – Embedding AI algorithms within modern CAD platforms (Fusion 360, SolidWorks, CATIA) for real-time design suggestions and updates.
- **Additive Manufacturing (3D Printing) Integration** – Designing AI-generated geometries optimized for additive and hybrid manufacturing processes.
- **Sustainable Design & Material Innovation** – Using AI to optimize materials, minimize waste, and improve eco-friendly design strategies.
- **Design Space Exploration Algorithms** – Applying multi-objective optimization (e.g., genetic algorithms, Bayesian optimization) for fast evaluation of design trade-offs.
- **AI-Based Product Customization** – Creating adaptive, user-specific product models for personalized solutions in industries like biomedical implants, automotive parts, or consumer electronics.
- **Simulation-Driven Design Validation** – Using CAE tools integrated with AI for virtual testing of strength, durability, and thermal performance of generated models.
- **Human-AI Collaborative Creativity** – Combining human intuition with AI-suggested design concepts to boost innovation and reduce design cycles.
- **Full-Stack Product Innovation Platforms** – Developing end-to-end workflows that integrate AI design engines, visualization dashboards, and rapid prototyping systems.

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AI-Based Generative Design for Lightweight Structural Components

Dr. B Vijaya Krishna, Assistant Professor, Dept. of ME - Faculty Mentor

GOAL

This project aims to harness the power of Artificial Intelligence (AI) and Generative Design to create lightweight structural components that do not compromise on strength, durability, or manufacturability. Traditional structural design often results in over-engineered components due to safety factors and manual optimization limitations. Generative Design, powered by AI algorithms, can rapidly explore and evaluate thousands of design alternatives that satisfy mechanical performance requirements while minimizing material use and weight.

The central goal of this project is to develop a design framework that automatically generates and evaluates lightweight, load-bearing structures—ideal for applications in aerospace, automotive, civil infrastructure, and biomedical devices. By integrating AI with topology optimization, parametric modeling, and simulation-driven validation, the project supports the creation of next-generation components that are both efficient and sustainable.

Key Goals:

- Automate the creation of structurally efficient, lightweight geometries using AI.
- Optimize material distribution based on applied loads and boundary conditions.
- Reduce design cycle time and improve product performance.
- Integrate AI-generated geometries into standard CAD/CAE workflows.
- Support sustainable engineering by minimizing resource usage.

METHODS & TECHNOLOGIES

Methods (Process & Approach):

The methodology revolves around generative algorithms, AI-based design exploration, and CAE-based simulation feedback to evolve optimal lightweight solutions.

- **Design Requirements and Boundary Definition:**
  Specify functional loads, supports, safety factors, material types, and fabrication constraints (e.g., additive manufacturing or CNC milling).
- **Generative Design Algorithm Implementation:**
  Use AI-guided topology optimization to evolve design spaces based on performance objectives. Implement deep learning models (e.g., Convolutional Neural Networks, VAEs) for geometric synthesis and refinement.
- **Iterative Simulation and Evaluation:**
  Run FEA (Finite Element Analysis) simulations on generated components to assess structural integrity, stiffness-to-weight ratio, and failure thresholds.
- **Design Space Exploration with Reinforcement Learning:**
  Apply reinforcement learning agents to iteratively propose modifications and converge to optimal geometries with minimal mass and maximum performance.
- **Conversion to Manufacturable CAD Models:**
  Post-process generative outputs into editable, parametric CAD models. Validate designs for manufacturability using DFM (Design for Manufacturing) principles.
- **Validation and Prototyping:**
  Fabricate select designs using 3D printing or CNC and test under physical conditions. Use results to fine-tune the AI model.

Technologies Used:

- **AI & ML Libraries:** TensorFlow, PyTorch, Keras, DEAP (Evolutionary algorithms), OpenAI Gym (for RL)
- **Optimization Tools:** Altair OptiStruct, ANSYS Topology Optimization, Autodesk Generative Design
- **CAD/CAE Platforms:** Fusion 360, SolidWorks, Siemens NX, ANSYS Mechanical
- **Programming:** Python, C++, MATLAB

MAJORS & AREAS OF INTEREST

This Cornerstone Project (CoP) is ideal for students from Mechanical Engineering, Design Engineering, Computer Science, and Industrial Design with interests in AI-driven product development and next-gen CAD workflows. Key areas of focus include:

- **Generative Design & Topology Optimization** – Exploring lightweight, high-performance structures by using AI-powered optimization techniques to reduce material usage and enhance functionality.
- **AI for Parametric & Algorithmic Design** – Developing AI/ML models (e.g., deep generative models, reinforcement learning) to automate parametric geometry generation and shape exploration.
- **AI-Integrated CAD Modelling** – Embedding AI algorithms within modern CAD platforms (Fusion 360, SolidWorks, CATIA) for real-time design suggestions and updates.
- **Additive Manufacturing (3D Printing) Integration** – Designing AI-generated geometries optimized for additive and hybrid manufacturing processes.
- **Sustainable Design & Material Innovation** – Using AI to optimize materials, minimize waste, and improve eco-friendly design strategies.
- **Design Space Exploration Algorithms** – Applying multi-objective optimization (e.g., genetic algorithms, Bayesian optimization) for fast evaluation of design trade-offs.
- **AI-Based Product Customization** – Creating adaptive, user-specific product models for personalized solutions in industries like biomedical implants, automotive parts, or consumer electronics.
- **Simulation-Driven Design Validation** – Using CAE tools integrated with AI for virtual testing of strength, durability, and thermal performance of generated models.
- **Human-AI Collaborative Creativity** – Combining human intuition with AI-suggested design concepts to boost innovation and reduce design cycles.
- **Full-Stack Product Innovation Platforms** – Developing end-to-end workflows that integrate AI design engines, visualization dashboards, and rapid prototyping systems.

By enabling AI-driven exploration of high-performance, low-mass structures, the project fosters innovation, sustainability, and efficiency in modern engineering design. It empowers students and industries to adopt data-driven, creative, and future-ready approaches to structural engineering challenges.

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Design Automation using NLP and Computer Vision for Drawing Interpretation

Dr. V V S H Prasad, Professor, Dept. of ME - Faculty Mentor

GOAL

This project aims to develop an intelligent system that automates the interpretation of engineering drawings using Natural Language Processing (NLP) and Computer Vision (CV) techniques, bridging the gap between human-readable specifications and machine-executable design workflows. In traditional design and drafting environments, significant time and effort are spent on manually reading, interpreting, and digitizing technical drawings, annotations, and engineering notes.

The goal is to create an AI-powered design automation system capable of extracting, understanding, and converting 2D CAD drawings, scanned blueprints, and technical documents into structured digital models or design parameters. This system enables faster design iterations, reduces manual errors, and supports seamless integration into CAD/CAE environments, making it especially useful in domains like civil, mechanical, electrical, and architectural design.

Key Goals:

- Automate extraction of geometric and textual features from engineering drawings.
- Interpret annotations, dimensions, and technical notes using NLP and CV.
- Convert unstructured drawing content into structured design data.
- Integrate interpreted data into CAD systems for rapid model generation.
- Improve productivity and accuracy in design engineering workflows.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

The project combines image processing, text recognition, and semantic understanding to interpret design intent from engineering drawings.

- **Data Acquisition & Preprocessing:**
  Gather diverse engineering drawings (2D CAD, scanned PDFs, hand sketches). Preprocess using denoising, binarization, and edge detection for clarity.
- **Computer Vision for Drawing Analysis:**
  Use CV techniques (OpenCV, CNNs) to detect lines, shapes, symbols, and geometric features. Identify structural elements (e.g., beams, holes, threads) and dimension lines.
- **Text Extraction using OCR:**
  Apply Optical Character Recognition (OCR) tools (e.g., Tesseract, EasyOCR) to extract dimension values, notes, material specs, and labels from drawings.
- **NLP for Semantic Understanding:**
  Use NLP models (e.g., BERT, spaCy) to understand textual descriptions, tolerances, and assembly instructions. Translate specifications and notes into structured metadata.
- **Design Parameter Generation:**
  Convert interpreted geometry and metadata into design parameters (e.g., dimensions, constraints). Auto-generate design templates or parametric models using APIs.
- **CAD Integration and Automation:**
  Use APIs (e.g., Autodesk Forge, SolidWorks API) to feed parameters into CAD tools for auto-model generation. Enable users to validate or edit generated models.

- **Testing & Validation:**
  Compare generated outputs with original designs for accuracy and completeness. Refine models using user feedback and error analysis.

Technologies Used

- **Computer Vision & OCR:** OpenCV, EasyOCR, Detectron2, PyTesseract
- **Machine Learning:** TensorFlow, Keras, Scikit-learn
- **CAD Platforms & APIs:** AutoCAD, SolidWorks, Fusion 360, Autodesk Forge API
- **Programming Languages:** Python (primary), JavaScript (for CAD integration)

MAJORS & AREAS OF INTEREST

This project is ideal for students from Mechanical Engineering, Civil Engineering, Electrical Engineering, Computer Science, and Architectural Design who are interested in AI-powered design automation and intelligent CAD workflows. Key focus areas include:

- **Natural Language Processing for Technical Data Extraction** – Applying NLP techniques (e.g., entity recognition, text parsing) to interpret annotations, dimensions, and engineering notes in drawings.
- **Computer Vision for Drawing Recognition** – Using deep learning-based CV models (e.g., CNNs, YOLO, Vision Transformers) for detecting geometric features, symbols, and layout structures in CAD drawings or scanned blueprints.
- **2D-to-3D Design Conversion** – Automating the transformation of 2D engineering drawings into 3D parametric models and structured design parameters.
- **Optical Character Recognition (OCR) & Handwriting Analysis** – Extracting and digitizing handwritten notes, labels, and technical specifications from legacy drawings.
- **CAD/CAE Integration** – Developing automated workflows that connect interpreted design data directly with CAD platforms like SolidWorks, AutoCAD, or Fusion 360.
- **AI-Powered Design Workflows** – Leveraging hybrid NLP-CV models to create machine-executable design processes that minimize human intervention.
- **Automation of Multi-Disciplinary Design Interpretation** – Supporting civil, mechanical, electrical, and architectural drawings for cross-domain use cases.
- **Error Detection & Validation** – Building AI tools to check for inconsistencies, missing annotations, or incorrect dimensions in technical documents.
- **Design Knowledge Representation** – Creating structured databases or knowledge graphs from extracted design data for advanced querying and reuse.
- **Productivity Enhancement in Design Engineering** – Reducing time-intensive manual reading and digitization processes through end-to-end AI-driven automation.

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Sustainable Product Design using AI and Lifecycle Assessment (LCA)

Dr. GVR Seshagiri Rao, Professor, Dept. of ME - Faculty Mentor

GOAL

This project focuses on leveraging Artificial Intelligence (AI) to support sustainable product design by integrating Lifecycle Assessment (LCA) into the early design stages. In conventional design workflows, environmental impacts are often evaluated late in the process—when design modifications are costly or infeasible. The goal here is to use AI to provide early-stage sustainability feedback**,** guiding designers toward environmentally responsible choices from the outset. The project aims to develop an intelligent system that automates the evaluation of material choices, energy consumption, emissions, and end-of-life disposal impacts using AI models trained on historical LCA data. Designers can then iteratively optimize products based on eco-efficiency**,** carbon footprint**,** resource circularity**,** and recyclability, thereby aligning innovation with global sustainability goals.

Key Goals:

- Integrate LCA into AI-powered product design workflows.
- Predict environmental impacts of design alternatives in real-time.
- Support sustainable decision-making in material selection and geometry.
- Promote circular economy principles (reuse, recycle, reduce) in product development.
- Enable designers to balance performance, cost, and sustainability.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

This project combines product modelling, AI-based prediction, and LCA databases to enable data-driven sustainable design.

- **Design Data Collection & Modeling:**
  Use CAD/CAE tools to define product geometry, assembly structure, and material specifications. Extract relevant attributes (e.g., volume, weight, material type, surface area).
- **Lifecycle Inventory (LCI) Integration:**
  Connect to LCA databases such as Ecoinvent, GaBi, or OpenLCA. Retrieve impact data for materials, manufacturing processes, logistics, and disposal.
- **AI Model Development for Impact Prediction:**
  Train regression or classification models (e.g., Random Forest, XGBoost, Neural Networks) on historical product-LCA data. Predict multiple sustainability metrics: CO_2 emissions, water usage, energy footprint, recyclability score, etc.
- **Optimization of Design Parameters:**
  Use AI/ML or genetic algorithms to recommend design alternatives with lower environmental impact. Provide real-time sustainability scores for design variants.
- **Dashboard & Visualization Tools:**
  Develop an interactive dashboard that displays LCA results and AI recommendations. Use visual indicators (color codes, graphs) to help designers understand trade-offs.
- **Feedback Loop for Continuous Improvement:**
  Allow designers to modify geometry or material selection based on insights. Iterate and refine to achieve sustainability and performance balance.

Technologies Used

- **AI/ML Frameworks:** Scikit-learn, TensorFlow, PyTorch, XGBoost
- **LCA Tools & Databases:** OpenLCA, Brightway2, Ecoinvent, GaBi
- **CAD/CAE Integration:** Autodesk Inventor, SolidWorks, Fusion 360 APIs
- **Visualization:** Streamlit, Dash, Plotly, Power BI
- **Programming Languages:** Python (primary), R

MAJORS & AREAS OF INTEREST

This project sits at the convergence of product design, AI, sustainability, and industrial engineering, attracting a diverse group of students and professionals.

- **AI for Lifecycle Assessment (LCA) Automation** – Applying machine learning models to predict environmental impacts (carbon footprint, energy use, emissions) of design choices early in the product development cycle.
- **Sustainable Product Design & Eco-Efficiency** – Exploring AI-assisted material selection, lightweighting, and eco-friendly geometry optimization to minimize environmental harm.
- **Data-Driven Material and Energy Analysis** – Building AI models trained on historical LCA databases (e.g., ecoinvent) to evaluate energy flows, recyclability, and resource use.
- **Integration of Circular Economy Principles** – Designing for reuse, recyclability, and reduced waste, guided by AI-driven recommendations.
- **Multi-Objective Optimization for Sustainability** – Balancing performance, cost, durability, and environmental impact using optimization algorithms.
- **Environmental Simulation and Predictive Modeling** – Using AI-enhanced tools to simulate emissions, water usage, and end-of-life disposal scenarios.
- **Green Manufacturing and Process Planning** – Incorporating sustainable manufacturing practices like additive manufacturing, remanufacturing, or low-energy production.

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AI-Based Design for Additive Manufacturing (DfAM) and Topology Optimization

Dr. K RaghuRam M Reddy, Associate Professor, Dept. of ME - Faculty Mentor

GOAL

This project aims to revolutionize the Design for Additive Manufacturing (DfAM) process by integrating Artificial Intelligence (AI) and Topology Optimization techniques. Traditional design paradigms often underutilize the geometric freedom offered by 3D printing, leading to over-engineered or inefficient components. Additive Manufacturing (AM) unlocks opportunities for material efficiency, weight reduction, and performance enhancement—but realizing this potential requires intelligent, automated design exploration.

The goal of this project is to develop an AI-powered system that automates DfAM by optimizing component geometry for lightweight, strength, printability, and material efficiency. It combines topology optimization (removing unnecessary material while maintaining structural performance) with AI models that learn from successful design outcomes. The system generates manufacturable geometries tailored to the specific capabilities of 3D printing technologies (SLS, FDM, SLA, etc.), and delivers recommendations on support minimization, orientation, and material use.

Key Goals:

- Develop AI-assisted DfAM tools that generate optimized, printable component geometries.
- Apply topology optimization to reduce material usage while maintaining mechanical integrity.
- Minimize support structures, print time, and post-processing effort via AI guidance.
- Improve product performance, customization, and time-to-market in design workflows.
- Foster sustainable manufacturing by reducing material waste and energy use.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

This project integrates generative AI, physics-based simulation, and advanced optimization within a CAD-AM workflow.

- **Input Collection & Constraints Definition:**
  Define load cases, boundary conditions, material properties, and functional requirements. Import initial CAD geometry or create parametric base designs.
- **Topology Optimization:**
  Use FEM-based solvers (e.g., SIMP, ESO) to remove non-critical material. Optimize for stiffness-to-weight ratio, natural frequency, or thermal performance.
- **AI-Powered Design Exploration:**
  Train ML models (e.g., CNNs, GNNs, VAEs) on databases of optimized structures. Generate new design variants or predict optimal topologies for new constraints.
- **Design for Manufacturability in AM:**
  Analyze print orientation, overhang angles, support requirements. Apply AI to suggest design changes for better printability and surface finish.
- **Simulation & Validation:**
  Run stress, thermal, or modal simulations on AI-generated models. Compare performance metrics (e.g., safety factor, deformation, fatigue life).

- **Export to AM Systems:**
  Convert final geometry to STL/AMF/G-code. Integrate with 3D printing slicers for build preparation and orientation control.

Technologies Used

- **Topology Optimization Tools:** Altair Inspire, Autodesk Fusion 360 Generative Design, ANSYS Mechanical
- **AI & ML Libraries:** PyTorch, TensorFlow, Scikit-learn, DeepMind-style graph networks
- **Simulation Software:** Abaqus, COMSOL, Ansys Workbench
- **AM Design Tools:** Netfabb, nTopology
- **CAD & Geometry Platforms:** SolidWorks
- **Visualization & Programming:** Python, Blender (for visualization)

MAJORS & AREAS OF INTEREST

This interdisciplinary project bridges design engineering, computational mechanics, AI, and additive manufacturing, making it suitable for students from the following backgrounds:

- **AI for Design for Additive Manufacturing (DfAM)** – Leveraging machine learning models to generate complex geometries optimized for 3D printing technologies (SLS, FDM, SLA, DMLS).
- **Topology Optimization & Lightweight Structures** – Using advanced optimization algorithms to remove unnecessary material while maintaining or improving mechanical performance.
- **Generative Geometry Creation** – Developing AI-driven generative models that explore thousands of design alternatives for weight reduction and structural efficiency.
- **Process-Aware Design Automation** – Designing components tailored to specific AM constraints like build orientation, layer thickness, and thermal effects.
- **Support Structure Reduction & Printability Optimization** – Utilizing AI and simulation to minimize support structures, reduce print time, and lower post-processing costs.
- **Multi-Material and Functionally Graded Design** – Exploring AI-guided material distribution for hybrid and multi-material 3D printing.
- **Sustainable Additive Manufacturing** – Focusing on minimizing material waste, energy use, and improving recyclability of printed components.
- **Simulation-Driven Performance Validation** – Integrating CAE tools (ANSYS, Abaqus) for stress, thermal, and fatigue validation of AI-generated designs.
- **Customization & Mass Personalization** – Using AI to create user-specific or on-demand custom components optimized for both performance and manufacturability.
- **Integration of AI with CAD & AM Workflows** – Building end-to-end AI-enhanced pipelines that connect design generation, topology optimization, and direct 3D printing execution.

AI-powered DfAM unlocks the full potential of 3D printing to deliver customized, optimized, and sustainable products, accelerating the shift from subtractive to resource-conscious additive manufacturing.

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Deep Learning for Adaptive Mesh Refinement in Structural FEM Simulation

Dr. V V S Prasad, Professor, Dept. of ME - Faculty Mentor

GOAL

This project explores the integration of Deep Learning (DL) with Finite Element Method (FEM) simulations to enable adaptive mesh refinement (AMR) in structural analysis. Traditional FEM simulations require careful mesh design—fine meshes improve accuracy but drastically increase computational cost, while coarse meshes reduce computation but may miss critical stress concentrations or discontinuities.

The goal is to develop AI-driven mesh refinement strategies that dynamically adjust mesh density based on the evolving stress, strain, or displacement fields during simulation. By using deep learning models trained on historical FEM data, the system will learn to predict where and when mesh refinement is needed, significantly reducing computation time while preserving simulation accuracy. This accelerates the design-validation cycle in structural engineering and enables real-time or near-real-time performance prediction in digital twin systems.

Key Goals:

- Develop deep learning models that guide adaptive mesh refinement in structural FEM.
- Improve simulation efficiency without sacrificing accuracy in stress-strain prediction.
- Enable faster convergence and reduced manual intervention in mesh generation.
- Integrate AI models with commercial FEM tools for seamless analysis workflows.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

This project combines data-driven learning with physics-based simulation, creating a feedback loop between mesh generation, FEM analysis, and AI-based prediction.

- **Data Collection & FEM Baseline Simulation:**
  Run traditional FEM simulations on structural components with varying loads, constraints, and materials. Collect mesh, displacement, stress field, and convergence data at each iteration.
- **Feature Engineering:**
  Extract features such as local error estimates, element aspect ratio, boundary proximity, and stress gradients. Normalize and encode geometrical and topological information into grid- or graph-based formats.
- **Deep Learning Model Development:**
  Use CNNs or GNNs to process spatial FEM data and predict mesh density requirements. Classify or regress refinement indicators (e.g., areas needing subdivision or coarsening).
- **Adaptive Mesh Refinement Strategy:**
  Integrate predictions into a mesh generation module to refine/coarsen elements dynamically. Iterate simulation with updated meshes until convergence criteria are met.
- **Validation & Benchmarking:**
  Compare AI-guided mesh strategies with traditional uniform and manually-refined meshes. Assess accuracy, time savings, and mesh quality using standard benchmarks.
- **Integration with CAE Tools:**

Interface the AI module with commercial or open-source FEM solvers (e.g., ANSYS, Abaqus, FEniCS). Automate the end-to-end pipeline from pre-processing to result visualization.

Technologies Used

- **FEM Simulation Platforms:** Abaqus, Ansys, FEniCS, COMSOL Multiphysics
- **Deep Learning Libraries:** PyTorch, TensorFlow, Keras
- **Geometric DL Frameworks:** PyG (PyTorch Geometric), DGL, MeshCNN, PointNet++
- **Mesh Tools:** Gmsh, Netgen, TetGen, OpenMesh
- **Programming Languages:** Python (core), C++ (for FEM integration), MATLAB (optional validation)
- **Visualization:** Matplotlib

MAJORS & AREAS OF INTEREST

This project is ideal for students and researchers from the following disciplines:

- **Finite Element Method (FEM) & Structural Analysis** – Understanding stress-strain behavior, boundary conditions, and mesh-based numerical methods for complex structural components.
- **Deep Learning for Simulation Optimization** – Applying neural networks (e.g., CNNs, GNNs, or physics-informed neural networks) to predict regions requiring mesh refinement.
- **Adaptive Mesh Refinement (AMR) Strategies** – Developing AI-driven methods to dynamically adjust mesh density for balancing accuracy and computation speed.
- **Data-Driven Modeling of Stress & Strain Fields** – Using historical FEM datasets to train deep learning models that identify high-gradient or high-stress zones.
- **Integration with FEM Tools** – Automating mesh refinement workflows in commercial platforms like ANSYS, Abaqus, COMSOL, or OpenFOAM using AI-driven scripts and APIs.
- **Reduced Computational Cost & Faster Convergence** – Enhancing simulation efficiency for high-resolution structural models by minimizing manual mesh design iterations.
- **Digital Twin Applications** – Leveraging adaptive FEM with AI to support real-time or near-real-time performance prediction and structural health monitoring.
- **Hybrid AI-Physics Models** – Combining data-driven DL approaches with physics-based constraints to ensure accuracy and reliability of refined meshes.
- **Uncertainty Quantification & Error Control** – Using AI to predict and minimize numerical errors due to discretization in FEM simulations.
- **High-Performance Computing & GPU Acceleration** – Implementing AI-enhanced FEM workflows on parallel and distributed systems for large-scale engineering problems.

By automating and accelerating mesh refinement with deep learning, this project lays the groundwork for next-generation simulation tools that are intelligent, adaptive, and capable of handling increasingly complex engineering challenges.

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AI-Supported Prosthetic Limb Design for Custom Fit and Functionality

Dr. C Labesh Kumar, Assistant Professor, Dept. of ME - Faculty Mentor

GOAL

This project focuses on leveraging Artificial Intelligence (AI) to revolutionize the design of prosthetic limbs, ensuring they are not only custom-fitted to individual users but also optimized for comfort, functionality, and biomechanics. Traditional prosthetic design is often time-consuming, relies heavily on manual measurements and iterations, and may not fully accommodate the unique anatomical and lifestyle needs of each individual.

The goal is to develop an AI-driven pipeline that automates and enhances the design process by integrating 3D scanning, biomechanical modeling, and data-driven design optimization. This includes using machine learning to predict user-specific design parameters, optimize material distribution for strength and weight, and simulate motion for real-world tasks. The project aims to deliver high-performance, personalized prosthetics that improve mobility, comfort, and quality of life for users.

Key Goals:

- Enable AI-powered customization of prosthetic limbs based on user anatomy and movement data.
- Improve fit, durability, and performance using biomechanical and ergonomic optimization.
- Reduce design iteration time and production costs using generative design techniques.
- Integrate simulation and predictive modeling to assess prosthetic functionality before fabrication.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

This project integrates multiple technologies to streamline the end-to-end prosthetic design workflow—from scanning and modeling to simulation and manufacturing.

- **User Data Acquisition:**
  Use 3D body scanning or medical imaging (CT/MRI) to capture limb geometry. Collect gait data and joint motion using IMUs, motion capture, or force sensors.
- **Biomechanical Analysis:**
  Simulate limb dynamics using inverse kinematics and force-displacement models. Identify stress points, range of motion, and load distribution for different activities.
- **AI-Based Design Customization:**
  Use machine learning regression/classification to map user data to design parameters (e.g., socket shape, stiffness zones). Apply generative design algorithms to explore multiple lightweight structural configurations.
- **Simulation & Optimization:**
  Perform Finite Element Analysis (FEA) to simulate stress and deformation under usage. Optimize for weight, comfort, mechanical strength, and energy return using multi-objective optimization.
- **Prototyping & Feedback Loop:**
  Fabricate using 3D printing with suitable materials (TPU, carbon fiber, biocompatible polymers). Incorporate user feedback and performance data to iteratively improve the design.

Technologies Used

- **Hardware:** 3D scanners, IMU sensors, force plates, additive manufacturing systems
- **CAD & Generative Design:** Autodesk Fusion 360, SolidWorks, Rhino + Grasshopper
- **Simulation:** Abaqus, Ansys, OpenSim for biomechanical modeling
- **Machine Learning:** Python (scikit-learn, TensorFlow, PyTorch)
- **Data Visualization:** Matplotlib
- **Programming Languages:** Python, MATLAB, C++
- **Fabrication:** FDM/Resin-based 3D printing, SLA for biocompatible materials

MAJORS & AREAS OF INTEREST

This multidisciplinary project suits students and researchers from diverse domains:

- **AI-Powered Customization & Generative Design** – Using machine learning models to generate personalized prosthetic designs tailored to an individual's anatomy, gait, and activity level.
- **3D Scanning & Reverse Engineering** – Leveraging 3D scanning and imaging technologies to capture user-specific anatomical data for accurate modeling.
- **Biomechanical Analysis & Motion Simulation** – Developing digital models of limb mechanics to evaluate range of motion, load distribution, and ergonomic comfort.
- **Lightweight Material Optimization** – Using topology optimization and AI-guided material selection to minimize weight while maintaining strength and durability.
- **Additive Manufacturing for Prosthetics** – Designing AI-generated prosthetics optimized for 3D printing to reduce production time and costs.
- **Human-Centric Design & Ergonomics** – Enhancing comfort and usability by integrating user feedback and biomechanical studies into the AI-driven design pipeline.
- **Predictive Modeling of Performance** – Simulating real-world activities (e.g., walking, climbing) to predict prosthetic performance and durability before fabrication.
- **Data-Driven Fit and Comfort Analysis** – Applying deep learning to analyze gait patterns, sensor data, and pressure points to fine-tune prosthetic geometry.
- **Integration of IoT & Smart Sensors** – Enabling smart prosthetics with embedded sensors for real-time monitoring and adaptive adjustments.
- **Healthcare-Oriented Design Innovation** – Aligning with the principles of personalized medicine and improving the quality of life for prosthetic users.

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AI-Enabled Virtual Prototyping and Rapid Design Validation

Dr. K RaghuRam M Reddy, Associate Professor, Dept. of ME - Faculty Mentor

GOALS

The project on AI-Enabled Virtual Prototyping and Rapid Design Validation aims to transform the traditional product development cycle by integrating Artificial Intelligence (AI) with virtual simulation environments. Instead of relying solely on physical prototypes—which are time-consuming and expensive—this approach leverages AI-driven digital models and simulations to design, test, validate, and iterate products in a virtual space.

By using AI to predict performance metrics, identify design flaws, and suggest modifications early in the design process, this method significantly reduces cost, time-to-market, and design risk. The ultimate goal is to create an intelligent virtual environment that supports real-time design optimization, failure prediction, and automated testing, enabling faster and smarter decision-making.

Key Goals:

- Enable AI-assisted virtual prototyping for early-stage product evaluation and concept validation.
- Automate simulation workflows and design iteration loops for faster time-to-market.
- Use AI to predict structural, thermal, fluid, and ergonomic performance.
- Improve design quality and reliability before physical prototyping begins.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

This project uses a combination of digital twin concepts, machine learning, and simulation tools to support a closed-loop virtual design-validation cycle.

- **CAD-Based Digital Prototyping:**
  Create initial 3D models of the product using CAD software. Use parametric modeling to allow quick variation and geometry updates.
- **Integration with AI Models:**
  Train ML models on historical simulation or test data to predict outcomes like stress, temperature, airflow, fatigue, etc. Use AI to generate performance feedback on new design variants in real time.
- **Simulation Automation:**
  Automate FEM, CFD, and motion simulations using Python or scripting tools. Run sensitivity analysis and optimization loops using AI-generated parameter sets.
- **AI-Driven Design Optimization:**
  Use reinforcement learning or genetic algorithms to explore optimal design configurations. Implement surrogate models (e.g., neural networks) to reduce simulation time.
- **Rapid Design Validation:**
  Compare virtual test results with real-world design goals and constraints. Identify failure modes and reliability risks through predictive analytics.
- **Human-in-the-Loop Evaluation:**
  Use XR/VR visualization tools for real-time design walkthroughs and ergonomic checks. Incorporate designer feedback into the AI loop for better results.

Technologies & Tools

- **CAD & Modeling Tools:** SolidWorks, CATIA, Autodesk Fusion 360
- **Simulation Platforms:** Ansys, Abaqus, COMSOL
- **AI & ML Tools:** Python, TensorFlow, scikit-learn, PyTorch
- **Optimization Frameworks:** MATLAB
- **Programming & Scripting:** Python, MATLAB, C++

MAJORS & AREAS OF INTEREST

This project encourages interdisciplinary collaboration and fits well across the following domains:

- **AI-Assisted Virtual Prototyping** – Using machine learning models to simulate and validate product concepts without the need for early physical prototypes.
- **Generative & Predictive Design** – Leveraging AI algorithms for automatic design optimization and performance prediction across multiple disciplines (structural, thermal, fluid, and ergonomic).
- **Simulation Automation & Workflow Optimization** – Creating AI-powered pipelines for automating CAE tasks (e.g., FEA, CFD, thermal analysis) and accelerating design iteration loops.
- **Digital Twin Development** – Building real-time virtual representations of products to monitor and test performance under simulated operating conditions.
- **Failure Prediction & Design Risk Analysis** – Training AI models to detect weak points, failure modes, and design inefficiencies early in the product development process.
- **Integration of CAD/CAE with AI Tools** – Connecting traditional design and simulation platforms (ANSYS, Abaqus, SolidWorks) with AI frameworks for intelligent decision-making.
- **Multiphysics Simulation & Optimization** – Applying AI to optimize products subjected to complex physical interactions (e.g., thermal-fluid-structural coupling).
- **Rapid Design Validation & Iteration** – Reducing time-to-market by replacing traditional prototype testing with AI-enhanced virtual validation.
- **Human-Centric Ergonomic Analysis** – Using AI-driven simulations to evaluate user interactions, ergonomics, and comfort factors.
- **Sustainable & Cost-Effective Product Development** – Minimizing resource-intensive physical prototyping while improving design quality and environmental impact.

By implementing virtual-first design approaches, this project enhances eco-friendly, resource-conscious engineering practices, while empowering future-ready professionals with skills in AI-augmented digital design and simulation.

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Autonomous Vehicle Component Design Optimization using AI

Dr. B Vijaya Krishna, Assistant Professor, Dept. of ME - Faculty Mentor

GOALS

This project focuses on leveraging Artificial Intelligence (AI) to optimize the design of critical components used in Autonomous Vehicles (AVs)—such as sensor mounts, control arms, braking systems, steering modules, battery enclosures, and aerodynamic panels. The integration of AI with design engineering accelerates the creation of high-performance, lightweight, and cost-effective components that meet the complex requirements of autonomy, safety, energy efficiency, and real-time responsiveness.

The goal is to develop intelligent, data-driven design systems that can automatically evaluate, generate, and improve component designs based on multi-objective criteria such as weight, strength, manufacturability, thermal performance, and integration with AV electronics and sensors.

Key Goals:

- Apply AI to optimize performance-critical components of autonomous vehicles.
- Use generative and predictive models to balance structural strength, weight, cost, and durability.
- Automate the iterative design and simulation cycle for faster innovation.
- Ensure that component designs meet the stringent safety and functionality needs of AV systems.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

This project combines Generative Design, Machine Learning, and Simulation-based Optimiztion to enable intelligent design workflows tailored for the autonomous mobility sector.

- **Component Modeling & Requirements Definition:**
  Use CAD software to define the geometry and constraints of AV components. Set performance targets such as fatigue life, load-bearing capacity, vibration resistance, and thermal management.
- **Generative Design Algorithms:**
  Employ AI-based generative design to explore thousands of feasible component geometries. Define optimization objectives (e.g., minimum weight with maximum strength) for structural elements.
- **Machine Learning for Performance Prediction:**
  Train ML models on historical FEA/CFD results to predict mechanical, thermal, or aerodynamic behavior. Use surrogate models to accelerate simulation and reduce computational load.
- **Simulation-Integrated Optimization Loop:**
  Integrate with FEM and CFD tools for evaluating each generated design. Apply AI to learn from simulation outputs and suggest better design alternatives.
- **Multi-Objective Optimization:**
  Use Genetic Algorithms or Reinforcement Learning to optimize trade-offs between competing criteria (e.g., lightweight vs durability). Ensure manufacturability and compatibility with AV architecture (battery packs, LiDAR, cameras, etc.).
- **Validation & Feedback:**
  Validate AI-generated designs with virtual and physical testing simulations. Incorporate feedback from domain experts and real-world conditions.

Technologies & Tools

- **CAD Tools:** SolidWorks, Autodesk Inventor, CATIA
- **Simulation Platforms:** Ansys, Abaqus
- **AI/ML Frameworks:** Python, TensorFlow, PyTorch, Scikit-learn, XGBoost
- **Generative Design Engines:** Autodesk Fusion 360 Generative Design, nTopology,
- **Optimization Tools:** MATLAB Optimization Toolbox
- **Data Integration & Preprocessing:** Pandas, NumPy
- **Programming/Scripting:** Python, MATLAB, C++

MAJORS & AREAS OF INTEREST

This project sits at the intersection of AI, design engineering, and automotive innovation, making it ideal for students from the following domains:

- **AI-Driven Component Optimization** – Applying machine learning and generative design techniques to optimize AV components (e.g., sensor mounts, brake systems, steering modules) for performance and reliability.
- **Lightweighting & Topology Optimization** – Designing weight-efficient components without compromising strength, crashworthiness, or manufacturability.
- **Integration with AV Sensors & Electronics** – Ensuring components are optimized for housing LiDAR, cameras, radar, and other AV hardware with thermal and structural considerations.
- **Simulation-Driven Design Validation** – Using AI-augmented CAE tools (e.g., ANSYS, Abaqus) for stress, thermal, vibration, and crash simulations to validate component performance.
- **Generative Design & Multi-Objective Optimization** – Balancing multiple criteria such as weight, cost, aerodynamics, durability, and safety in the design process.
- **Thermal Management & Battery Enclosure Design** – Optimizing thermal performance and safety of battery housings and electronic modules in AVs.
- **Aerodynamics & Energy Efficiency** – Using AI-based CFD simulations to design aerodynamic panels that improve range and energy consumption.
- **Automated Iterative Design Cycles** – Building AI-powered pipelines that accelerate design iterations and reduce time-to-market.
- **Sustainable Materials & Green Manufacturing** – Exploring recyclable, eco-friendly materials and design approaches for AV components.
- **Safety and Regulatory Compliance** – Ensuring AI-generated designs align with automotive safety standards and autonomous driving requirements.

By enabling intelligent component design for the next generation of autonomous vehicles, this project accelerates the shift toward safer, cleaner, and smarter mobility systems, while equipping students with high-demand skills in AI-powered design engineering.

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AI-Based Design of Impact-Absorbing Structures for Crash Safety

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GOALS

This project explores the application of Artificial Intelligence (AI) in designing impact-absorbing structures that enhance crash safety in vehicles, helmets, protective gear, and industrial equipment. Traditional crash safety design relies heavily on iterative finite element simulations and domain expertise, which can be time-consuming and suboptimal in exploring the full design space.

The goal of this project is to develop AI-driven design frameworks that intelligently generate, analyze, and optimize crashworthy structures with maximized energy absorption, minimal occupant injury risk, and efficient material usage. These include crumple zones, crash boxes, sandwich panels, and lattice structures designed to dissipate kinetic energy during impact.

Key Goals:

- Apply AI to optimize structural components for crash safety and energy absorption.
- Use simulation-informed machine learning to predict crash response under varied conditions.
- Accelerate design cycles through AI-driven generative and surrogate models.
- Ensure compliance with safety standards while minimizing weight and material costs.

METHODS & TECHNOLOGIES

Methods (Process & Approach)

This project blends machine learning, generative design, and impact simulation to evolve novel structures that protect users and equipment during collisions or accidents.

- **Data Collection & Simulation Benchmarking:**
  Generate datasets from crash simulations using FEM tools for different materials and geometries. Include strain, stress, deformation, acceleration, and energy absorption metrics.
- **Surrogate Modeling of Crash Response:**
  Train ML models to approximate the results of complex crash simulations. Predict impact response (e.g., G-forces, intrusion, crumple profile) based on design input.
- **Generative Design for Crashworthiness:**
  Use AI algorithms to explore and generate high-performance crashworthy structures. Employ topological and geometric optimization for components like bumpers, beams, and protective casings.
- **Multi-Objective Optimization:**
  Optimize for multiple goals: safety, weight reduction, space constraints, and manufacturability. Utilize Genetic Algorithms, Bayesian optimization, or Reinforcement Learning.
- **Virtual Testing and Validation:**
  Validate AI-generated designs using crash simulation software. Ensure regulatory compliance with crash test standards (e.g., Euro NCAP, FMVSS).
- **Iterative Learning and Human Feedback:**
  Include feedback from domain experts in materials and crash mechanics to refine models. Use active learning to improve prediction accuracy on difficult design regions.

Technologies & Tools

- **Simulation Tools:** ANSYS Explicit Dynamics, Abaqus
- **AI & ML Frameworks:** TensorFlow, PyTorch, Scikit-learn, XGBoost
- **Design & CAD Tools:** SolidWorks, CATIA
- **Generative & Optimization Platforms:** nTopology, MATLAB Genetic Algorithm Toolbox
- **Programming Languages:** Python, MATLAB, C++
- **Visualization Tools:** Plotly, Power BI for interpreting crash patterns and AI insights

MAJORS & AREAS OF INTEREST

This interdisciplinary project is ideal for students and researchers from multiple engineering domains:

- **AI for Crashworthy Design Optimization** – Using machine learning and generative design algorithms to create impact-absorbing structures such as crumple zones, crash boxes, and sandwich panels.
- **Surrogate Modeling & Simulation Acceleration** – Leveraging AI models trained on FEM crash simulation data to predict impact responses faster than traditional methods.
- **Energy Absorption & Kinetic Dissipation** – Designing lattice, honeycomb, and composite structures for optimal crash energy dissipation while minimizing weight.
- **Topology Optimization for Crash Safety** – Using AI-driven optimization techniques to remove non-essential material while maintaining safety performance.
- **Material Design & Selection** – Exploring advanced materials (composites, foams, lightweight alloys) optimized for crashworthiness through AI-guided modeling.
- **Finite Element Analysis (FEA) Integration** – Automating crash simulations in ANSYS, LS-DYNA, or Abaqus using AI-supported workflows for faster validation.
- **Multi-Objective Safety-Cost Optimization** – Balancing safety standards, occupant protection, and cost-effective design strategies.
- **Generative & Bio-Inspired Design** – Applying AI to develop innovative, nature-inspired structures (e.g., bone-like lattices) for enhanced impact absorption.
- **Lightweighting & Structural Efficiency** – Minimizing component mass while ensuring compliance with crash safety standards.
- **Regulatory Compliance & Testing** – Aligning AI-generated designs with global safety standards (e.g., NCAP, IIHS) through virtual validation and AI-accelerated testing.

By developing crashworthy structures using AI, the project contributes to next-generation safety engineering—empowering faster, smarter, and more ethical design of products that protect human life and reduce material impact.

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