

Data Science Projects - Academic Research Style

Machine Learning and Data Science Integration Across Engineering & Scientific Domains

Category 1: Civil & Structural Engineering (25 Projects)

1. Machine Learning and Computer Vision Assisted Crack Detection in Concrete Structures Using Deep Convolutional Neural Networks

Domain: Structural Health Monitoring **Techniques:** CNNs, Image Segmentation, Transfer Learning **Data Sources:** Concrete crack images, Structural inspection data **IEEE Keywords:** "Crack Detection", "CNN Structural Damage", "Computer Vision Infrastructure"

2. Predictive Analytics and IoT Sensor Fusion for Real-Time Bridge Health Monitoring and Fatigue Life Assessment

Domain: Bridge Engineering **Techniques:** Time Series Analysis, LSTM, Sensor Data Fusion **Data Sources:** Strain gauges, Accelerometers, Environmental sensors **IEEE Keywords:** "Bridge Health Monitoring", "IoT Structural Engineering", "Fatigue Prediction"

3. Deep Learning Based Seismic Response Prediction and Damage Assessment of RC Frame Structures Under Earthquake Loading

Domain: Earthquake Engineering **Techniques:** Deep Neural Networks, Regression, Classification **Data Sources:** Seismic records, Structural response data, Finite Element Analysis **IEEE Keywords:** "Seismic Response Prediction", "Earthquake Damage ML", "Structural Analysis"

4. Machine Learning Enabled Optimization of Mix Design Parameters for High Performance Self-Compacting Concrete

Domain: Construction Materials **Techniques:** Regression Models, Genetic Algorithms, Neural Networks **Data Sources:** Concrete mix proportions, Compressive strength tests **IEEE Keywords:** "Concrete Mix Design Optimization", "Material Property Prediction"

5. Data-Driven Analysis and Machine Learning Models for Predicting Settlement of Deep Foundations in Soft Clay

Domain: Geotechnical Engineering **Techniques:** Random Forest, XGBoost, Feature Engineering **Data Sources:** Soil properties, SPT/CPT data, Settlement records **IEEE Keywords:** "Foundation Settlement Prediction", "Geotechnical ML"

6. Convolutional Neural Networks and Image Processing for Automated Rebar Detection and Counting in Construction Sites

Domain: Construction Management **Techniques:** Object Detection (YOLO), Instance Segmentation **Data Sources:** Construction site images, Rebar inventory **IEEE Keywords:** "Construction Automation", "Rebar Detection", "Computer Vision Civil"

7. Machine Learning Assisted Prediction of Deflection in Composite Steel-Concrete Beams Under Service Loads

Domain: Structural Engineering **Techniques:** Ensemble Methods, Neural Networks, Regression Analysis **Data Sources:** Load-deflection data, Material properties, Beam geometry **IEEE Keywords:** "Deflection Prediction", "Composite Beam Analysis"

8. Deep Learning and Acoustic Emission Analysis for Early Detection of Corrosion in Prestressed Concrete Structures

Domain: Durability Assessment **Techniques:** Signal Processing, CNN, Anomaly Detection **Data Sources:** Acoustic emission signals, Corrosion measurements **IEEE Keywords:** "Corrosion Detection", "Acoustic Emission ML", "NDT Methods"

9. Data Mining and Predictive Modeling of Construction Project Delays Using Historical Project Data and Risk Factors

Domain: Construction Management **Techniques:** Classification, Association Rules, Decision Trees **Data Sources:** Project schedules, Delay causes, Resource allocation **IEEE Keywords:** "Construction Delay Prediction", "Project Management ML"

10. Machine Learning Enabled Prediction of Ultimate Load Capacity of Steel Columns Subjected to Axial Compression and Bending

Domain: Steel Structures **Techniques:** Support Vector Machines, Neural Networks, Ensemble Methods **Data Sources:** Column test data, Material properties, Geometric parameters **IEEE Keywords:** "Load Capacity Prediction", "Steel Column Analysis"

11. Computer Vision and Deep Learning for Automated Quality Control and Defect Detection in Precast Concrete Elements

Domain: Quality Control **Techniques:** Image Classification, Defect Detection, CNN **Data Sources:** Precast element images, Quality inspection records **IEEE Keywords:** "Defect Detection Manufacturing", "Quality Control Vision"

12. Data-Driven Approach for Predicting Liquefaction Potential of Soils Using Machine Learning and CPT Data

Domain: Earthquake Geotechnics **Techniques:** Random Forest, Logistic Regression, Neural Networks **Data Sources:** CPT profiles, Liquefaction case histories **IEEE Keywords:** "Liquefaction Prediction", "Soil Liquefaction ML"

13. Machine Learning Models for Estimating Energy Consumption in Residential Buildings Based on Design Parameters and Climate Data

Domain: Building Energy **Techniques:** Regression, Gradient Boosting, Feature Selection **Data Sources:** Building characteristics, Energy bills, Weather data **IEEE Keywords:** "Building Energy Prediction", "Energy Consumption ML"

14. Deep Neural Networks and Finite Element Analysis for Predicting Buckling Behavior of Thin-Walled Cold-Formed Steel Members

Domain: Structural Stability **Techniques:** Deep Learning, Physics-Informed Neural Networks **Data Sources:** FEA simulations, Experimental buckling data **IEEE Keywords:** "Buckling Prediction", "Cold-Formed Steel ML"

15. Machine Learning Assisted Traffic Flow Prediction and Optimization for Pavement Design Life Assessment

Domain: Transportation Engineering **Techniques:** Time Series Forecasting, LSTM, Traffic Modeling **Data Sources:** Traffic counts, Axle loads, Pavement condition **IEEE Keywords:** "Traffic Prediction", "Pavement Design ML"

16. Data Science Approach to Predicting Shear Strength of Reinforced Concrete Beams Without Stirrups Using ANN and GEP

Domain: Structural Design **Techniques:** Artificial Neural Networks, Genetic Expression Programming **Data Sources:** Beam test database, Shear failure data **IEEE Keywords:** "Shear Strength Prediction", "RC Beam ML"

17. Machine Learning and Image Analysis for Automated Assessment of Surface Roughness in Concrete Pavements

Domain: Pavement Engineering **Techniques:** Texture Analysis, CNN, Regression Models **Data Sources:** Pavement surface images, Roughness measurements **IEEE Keywords:** "Surface Roughness Assessment", "Pavement Texture Analysis"

18. Predictive Analytics for Remaining Useful Life Estimation of Highway Bridge Decks Using Inspection Data and Environmental Factors

Domain: Asset Management **Techniques:** Survival Analysis, Degradation Modeling, ML **Data Sources:** Bridge inspection records, Maintenance history **IEEE Keywords:** "Remaining Life Prediction", "Bridge Asset Management"

19. Deep Learning Based Classification of Soil Types from SPT-N Values and Physical Properties for Foundation Design

Domain: Soil Classification **Techniques:** Multi-class Classification, Neural Networks, Decision Trees **Data Sources:** SPT data, Soil properties, Borehole logs **IEEE Keywords:** "Soil Classification ML", "SPT Analysis"

20. Machine Learning Models for Predicting Creep and Shrinkage in High-Strength Concrete Structures Over Time

Domain: Long-term Behavior **Techniques:** Time Series Analysis, LSTM, Regression Models **Data Sources:** Long-term deformation measurements, Concrete properties **IEEE Keywords:** "Creep Prediction", "Concrete Long-term Behavior"

21. Computer Vision and Deep Learning for Automated Damage Assessment of Buildings After Natural Disasters

Domain: Disaster Management **Techniques:** Image Classification, Damage Detection, Semantic Segmentation **Data Sources:** Post-disaster imagery, Damage reports **IEEE Keywords:** "Disaster Damage Assessment", "Building Damage Detection"

22. Data-Driven Prediction of Thermal Performance in Green Building Envelopes Using Machine Learning Techniques

Domain: Sustainable Buildings **Techniques:** Regression, Neural Networks, Feature Importance **Data Sources:** Thermal measurements, Building materials, Climate data **IEEE Keywords:** "Thermal Performance Prediction", "Green Building ML"

23. Machine Learning Enabled Prediction of Punching Shear Capacity in Reinforced Concrete Flat Slabs

Domain: Slab Design **Techniques:** Ensemble Learning, Neural Networks, Support Vector Regression **Data Sources:** Punching shear tests, Slab configurations **IEEE Keywords:** "Punching Shear Prediction", "Flat Slab Analysis"

24. Deep Learning and Photogrammetry for 3D Reconstruction and Volume Estimation in Earthwork Construction Projects

Domain: Construction Technology **Techniques:** 3D CNN, Point Cloud Processing, Volume Calculation **Data Sources:** Drone imagery, LiDAR data, Survey measurements **IEEE Keywords:** "3D Reconstruction Construction", "Earthwork Volume Estimation"

25. Machine Learning Framework for Predicting Wind-Induced Response of High-Rise Buildings Using Computational Fluid Dynamics Data

Domain: Wind Engineering **Techniques:** Neural Networks, CFD Integration, Response Prediction **Data Sources:** CFD simulations, Wind tunnel tests, Response measurements **IEEE Keywords:** "Wind Response Prediction", "High-Rise Building ML"

Category 2: Mechanical & Manufacturing Engineering (20 Projects)

26. Machine Learning and Acoustic Signal Analysis for Predictive Maintenance and Fault Detection in Rotating Machinery

Domain: Condition Monitoring **Techniques:** Signal Processing, CNN, Anomaly Detection **Data Sources:** Vibration signals, Acoustic data, Failure records **IEEE Keywords:** "Bearing Fault Detection", "Predictive Maintenance ML"

27. Deep Learning Based Surface Roughness Prediction in CNC Milling Operations Using Cutting Parameters and Tool Wear Data

Domain: Machining **Techniques:** Regression, Neural Networks, Image Analysis **Data Sources:** Cutting parameters, Surface roughness measurements, Tool images **IEEE Keywords:** "Surface Roughness Prediction", "Machining Process ML"

28. Data-Driven Optimization of Welding Parameters for Maximum Joint Strength in Friction Stir Welding Using Machine Learning

Domain: Welding Technology **Techniques:** Optimization Algorithms, Regression, Response Surface Methodology **Data Sources:** Welding parameters, Joint strength tests, Microstructure analysis **IEEE Keywords:** "Welding Parameter Optimization", "FSW Machine Learning"

29. Convolutional Neural Networks for Automated Defect Detection and Classification in Additive Manufacturing Products

Domain: 3D Printing **Techniques:** Image Classification, Defect Detection, Transfer Learning **Data Sources:** Layer images, CT scans, Quality inspection data **IEEE Keywords:** "Defect Detection 3D Printing", "Additive Manufacturing QC"

30. Machine Learning Assisted Prediction of Tool Life and Wear Progression in Hard Turning of Alloy Steels

Domain: Tool Management **Techniques:** Time Series Analysis, Survival Analysis, Regression **Data Sources:** Tool wear measurements, Cutting forces, Tool life data **IEEE Keywords:** "Tool Wear Prediction", "Tool Life Estimation ML"

31. Deep Reinforcement Learning for Real-Time Optimization of Process Parameters in Injection Molding

Domain: Polymer Processing **Techniques:** Reinforcement Learning, Q-Learning, Process Control **Data Sources:** Process parameters, Product quality data, Sensor readings **IEEE Keywords:** "Injection Molding Optimization", "RL Manufacturing"

32. Data Mining and Machine Learning for Energy Consumption Prediction and Optimization in Manufacturing Operations

Domain: Energy Management **Techniques:** Time Series Forecasting, Clustering, Regression **Data Sources:** Energy meters, Production schedules, Machine parameters **IEEE Keywords:** "Manufacturing Energy Prediction", "Energy Optimization ML"

33. Computer Vision and Deep Learning for Automated Dimensional Inspection and Quality Control in Mass Production

Domain: Quality Assurance **Techniques:** Object Detection, Measurement Extraction, CNN **Data Sources:** Product images, CAD models, Measurement data **IEEE Keywords:** "Dimensional Inspection Vision", "Quality Control Automation"

34. Machine Learning Models for Predicting Fatigue Life of Mechanical Components Under Variable Amplitude Loading

Domain: Fatigue Analysis **Techniques:** Regression, Neural Networks, Cycle Counting **Data Sources:** Load histories, Fatigue test data, S-N curves **IEEE Keywords:** "Fatigue Life Prediction", "Variable Amplitude Loading ML"

35. Deep Learning Based Recognition and Classification of Machining Processes from Audio and Vibration Signatures

Domain: Process Monitoring **Techniques:** Signal Processing, CNN, Multi-class Classification **Data Sources:** Audio recordings, Vibration data, Process labels **IEEE Keywords:** "Process Recognition ML", "Machining Monitoring"

36. Data-Driven Approach for Predicting Springback in Sheet Metal Forming Using Material Properties and Process Parameters

Domain: Metal Forming **Techniques:** Regression, Neural Networks, FEM Data Integration **Data Sources:** Forming parameters, Springback measurements, Material tests **IEEE Keywords:** "Springback Prediction", "Sheet Metal Forming ML"

37. Machine Learning Enhanced Thermal Error Compensation in CNC Machine Tools for Improved Machining Accuracy

Domain: Precision Manufacturing **Techniques:** Regression, Thermal Modeling, Error Compensation **Data Sources:** Temperature sensors, Position errors, Machine kinematics **IEEE Keywords:** "Thermal Error Compensation", "CNC Accuracy ML"

38. Deep Neural Networks for Predicting Mechanical Properties of Friction Stir Processed Aluminum Alloys

Domain: Material Processing **Techniques:** Deep Learning, Property Prediction, Process-Property Correlation **Data Sources:** Process parameters, Mechanical tests, Microstructure data **IEEE Keywords:** "Mechanical Property Prediction", "FSP Aluminum ML"

39. Computer Vision and Machine Learning for Real-Time Weld Pool Monitoring and Quality Assessment in GMAW

Domain: Arc Welding **Techniques:** Image Processing, CNN, Real-time Classification **Data Sources:** Weld pool images, Current/voltage data, Weld quality **IEEE Keywords:** "Weld Pool Monitoring", "GMAW Quality Control"

40. Machine Learning Framework for Predicting Residual Stresses in Laser Powder Bed Fusion Additive Manufacturing

Domain: Metal AM **Techniques:** Neural Networks, Process Simulation Integration, Stress Prediction **Data Sources:** Process parameters, Residual stress measurements, Thermal history **IEEE Keywords:** "Residual Stress Prediction AM", "LPBF Machine Learning"

41. Data Science Approach to Production Planning and Scheduling Optimization in Job Shop Manufacturing Systems

Domain: Production Management **Techniques:** Genetic Algorithms, Simulated Annealing, ML-based Heuristics **Data Sources:** Production orders, Machine capabilities, Processing times **IEEE Keywords:** "Production Scheduling ML", "Job Shop Optimization"

42. Deep Learning Based Chatter Detection and Suppression in High-Speed Milling Operations

Domain: Machining Dynamics **Techniques:** Signal Processing, LSTM, Real-time Detection **Data Sources:** Vibration signals, Cutting parameters, Chatter occurrence **IEEE Keywords:** "Chatter Detection ML", "Machining Stability"

43. Machine Learning Models for Predicting Surface Integrity Parameters in Grinding of Hardened Steels

Domain: Finishing Operations **Techniques:** Multi-output Regression, Neural Networks, Feature Engineering **Data Sources:** Grinding parameters, Surface integrity measurements **IEEE Keywords:** "Surface Integrity Prediction", "Grinding Process ML"

44. Computer Vision and Deep Learning for Automated Weld Defect Detection in Radiographic Inspection

Domain: Non-Destructive Testing **Techniques:** Image Segmentation, Defect Classification, Transfer Learning **Data Sources:** X-ray images, Defect annotations, Inspection reports **IEEE Keywords:** "Weld Defect Detection", "Radiographic Inspection ML"

45. Data-Driven Predictive Modeling of Die Wear in Hot Forging Operations Using Process Variables

Domain: Forging **Techniques:** Regression, Time Series Analysis, Wear Modeling **Data Sources:** Die geometry, Process parameters, Wear measurements **IEEE Keywords:** "Die Wear Prediction", "Hot Forging ML"

Category 3: Electrical & Electronics Engineering (20 Projects)

46. Machine Learning and Smart Metering Data Analysis for Residential Load Forecasting and Demand Response

Domain: Power Systems **Techniques:** Time Series Forecasting, LSTM, Clustering **Data Sources:** Smart meter data, Weather data, Consumer profiles **IEEE Keywords:** "Load Forecasting", "Demand Response ML", "Smart Grid"

47. Deep Learning Based Fault Detection and Classification in Power Transformers Using Dissolved Gas Analysis

Domain: Power Equipment **Techniques:** Multi-class Classification, Neural Networks, Feature Selection **Data Sources:** DGA data, Transformer condition, Fault records **IEEE Keywords:** "Transformer Fault Detection", "DGA Analysis ML"

48. Convolutional Neural Networks for Automated PCB Defect Detection and Classification in Electronics Manufacturing

Domain: Electronics Quality Control **Techniques:** Image Classification, Defect Detection, Transfer Learning **Data Sources:** PCB images, Defect annotations, AOI data **IEEE Keywords:** "PCB Defect Detection", "Electronics Inspection ML"

49. Machine Learning Assisted Prediction of Remaining Useful Life in Lithium-Ion Batteries Using Capacity Fade Data

Domain: Battery Management **Techniques:** Regression, LSTM, Degradation Modeling **Data Sources:** Charge-discharge cycles, Capacity measurements, Temperature **IEEE Keywords:** "Battery RUL Prediction", "Li-ion Degradation ML"

50. Data-Driven Approach for Power Quality Disturbance Classification Using Wavelet Transform and Deep Learning

Domain: Power Quality **Techniques:** Signal Processing, CNN, Multi-class Classification **Data Sources:** Voltage/current waveforms, Disturbance labels **IEEE Keywords:** "Power Quality Classification", "Disturbance Detection ML"

51. Deep Reinforcement Learning for Optimal Energy Management in Microgrid Systems with Renewable Integration

Domain: Renewable Energy **Techniques:** Reinforcement Learning, Q-Learning, Energy Optimization **Data Sources:** Generation data, Load profiles, Energy prices **IEEE Keywords:** "Microgrid Energy Management", "RL Renewable Energy"

52. Machine Learning Models for Solar Irradiance Forecasting Using Satellite Imagery and Meteorological Data

Domain: Solar Energy **Techniques:** CNN, Time Series Analysis, Image Processing **Data Sources:** Satellite images, Weather data, Solar measurements **IEEE Keywords:** "Solar Irradiance Forecasting", "Solar Energy ML"

53. Computer Vision and Deep Learning for Automated Inspection of Solar Panel Defects Using Thermal and Visual Imaging

Domain: Solar PV **Techniques:** Image Fusion, Defect Detection, Anomaly Detection **Data Sources:** Thermal images, Visual images, Defect annotations **IEEE Keywords:** "Solar Panel Inspection", "PV Defect Detection"

54. Data Mining and Machine Learning for Electricity Theft Detection in Smart Grid Networks

Domain: Grid Security **Techniques:** Anomaly Detection, Classification, Pattern Mining **Data Sources:** Smart meter data, Consumption patterns, Theft cases **IEEE Keywords:** "Electricity Theft Detection", "Smart Grid Security ML"

55. Deep Learning Based State of Charge Estimation for Electric Vehicle Batteries Under Dynamic Driving Conditions

Domain: Electric Vehicles **Techniques:** LSTM, Neural Networks, Kalman Filtering **Data Sources:** Battery voltage/current, SOC measurements, Driving cycles **IEEE Keywords:** "SOC Estimation", "EV Battery Management ML"

56. Machine Learning Framework for Predicting Failure Modes in High Voltage Circuit Breakers Using Operational Data

Domain: Switchgear **Techniques:** Classification, Survival Analysis, Failure Prediction **Data Sources:** Operating counters, Maintenance records, Failure data **IEEE Keywords:** "Circuit Breaker Failure Prediction", "Switchgear ML"

57. Convolutional Neural Networks for Automated Classification of Cardiac Arrhythmias from ECG Signals

Domain: Biomedical Electronics **Techniques:** 1D CNN, Signal Processing, Multi-class Classification **Data Sources:** ECG recordings, Arrhythmia annotations, Patient data **IEEE Keywords:** "ECG Classification", "Arrhythmia Detection ML"

58. Data-Driven Optimization of Wireless Sensor Network Topology for Enhanced Energy Efficiency and Coverage

Domain: Sensor Networks **Techniques:** Genetic Algorithms, Optimization, Network Analysis **Data Sources:** Network topology, Energy consumption, Coverage metrics **IEEE Keywords:** "WSN Optimization", "Sensor Network ML"

59. Machine Learning and Signal Processing for Partial Discharge Pattern Recognition in High Voltage Equipment

Domain: Insulation Diagnostics **Techniques:** Pattern Recognition, Classification, Feature Extraction **Data Sources:** PD signals, Phase-resolved patterns, Defect types **IEEE Keywords:** "Partial Discharge Recognition", "Insulation Diagnosis ML"

60. Deep Learning Based Prediction of Electromagnetic Interference in Electronic Systems Using Layout and Component Data

Domain: EMC Design **Techniques:** Neural Networks, Simulation Data Integration, Prediction **Data Sources:** PCB layouts, Component specifications, EMI measurements **IEEE Keywords:** "EMI Prediction", "EMC Machine Learning"

61. Machine Learning Models for Wind Turbine Power Curve Modeling and Performance Assessment Using SCADA Data

Domain: Wind Energy **Techniques:** Regression, Neural Networks, Anomaly Detection **Data Sources:** SCADA data, Wind speed, Power output **IEEE Keywords:** "Wind Turbine Performance", "Power Curve ML"

62. Computer Vision and Deep Learning for Automated Recognition of Electrical Symbols in Engineering Drawings

Domain: CAD Automation **Techniques:** Object Detection, Symbol Recognition, Transfer Learning **Data Sources:** Electrical drawings, Symbol libraries, Annotations **IEEE Keywords:** "Symbol Recognition", "Engineering Drawing ML"

63. Data Science Approach to Transient Stability Assessment in Power Systems Using Synchrophasor Measurements

Domain: Power System Stability **Techniques:** Classification, Time Series Analysis, PMU Data Processing **Data Sources:** PMU data, Contingency scenarios, Stability outcomes **IEEE Keywords:** "Transient Stability Assessment", "PMU Data ML"

64. Machine Learning Enhanced Voltage Stability Prediction in Distribution Networks with High DER Penetration

Domain: Distribution Systems **Techniques:** Regression, Neural Networks, Voltage Analysis **Data Sources:** Voltage measurements, DER data, Network topology **IEEE Keywords:** "Voltage Stability Prediction", "DER Integration ML"

65. Deep Learning for Automated Diagnosis of Motor Bearing Faults Using Vibration and Current Signature Analysis

Domain: Motor Diagnostics **Techniques:** Multi-modal Learning, CNN, Fault Classification **Data Sources:** Vibration signals, Current signals, Fault labels **IEEE Keywords:** "Motor Fault Diagnosis", "Bearing Fault Detection ML"

Category 4: Chemical & Process Engineering (15 Projects)

66. Machine Learning Assisted Prediction of Distillation Column Performance Using Process Variables and Feed Composition

Domain: Separation Processes **Techniques:** Regression, Neural Networks, Process Modeling **Data Sources:** Operating data, Feed analysis, Product specifications **IEEE Keywords:** "Distillation Modeling", "Separation Process ML"

67. Deep Learning and Spectroscopy Data Analysis for Real-Time Quality Prediction in Pharmaceutical Manufacturing

Domain: Pharmaceutical Engineering **Techniques:** CNN, Regression, NIR/Raman Spectroscopy **Data Sources:** Spectral data, Quality parameters, Process conditions **IEEE Keywords:** "Pharmaceutical Quality Prediction", "Spectroscopy ML"

68. Data-Driven Modeling and Optimization of Polymerization Reactor Conditions for Desired Molecular Weight Distribution

Domain: Polymer Engineering **Techniques:** Optimization, Neural Networks, Multi-objective Optimization **Data Sources:** Reactor conditions, Molecular weight data, Conversion rates **IEEE Keywords:** "Polymerization Optimization", "Reactor Modeling ML"

69. Machine Learning Framework for Predicting Corrosion Rates in Oil and Gas Pipelines Using Environmental Factors

Domain: Corrosion Engineering **Techniques:** Regression, Time Series Analysis, Feature Engineering **Data Sources:** Corrosion measurements, Environment data, Pipeline parameters **IEEE Keywords:** "Corrosion Rate Prediction", "Pipeline Integrity ML"

70. Computer Vision and Deep Learning for Automated Crystal Size Distribution Analysis in Crystallization Processes

Domain: Crystallization **Techniques:** Image Segmentation, Particle Analysis, Size Distribution **Data Sources:** Microscope images, Crystal size data, Process conditions **IEEE Keywords:** "Crystal Size Analysis", "Crystallization Monitoring ML"

71. Machine Learning Models for Predicting Product Yield and Selectivity in Catalytic Chemical Reactions

Domain: Catalysis **Techniques:** Regression, Ensemble Methods, Feature Selection **Data Sources:** Reaction conditions, Catalyst properties, Yield data **IEEE Keywords:** "Reaction Yield Prediction", "Catalysis ML"

72. Data Science Approach to Fault Detection and Root Cause Analysis in Chemical Process Plants Using Alarm Data

Domain: Process Safety **Techniques:** Anomaly Detection, Association Rules, Time Series Analysis **Data Sources:** Alarm logs, Process variables, Incident reports **IEEE Keywords:** "Fault Detection Chemical", "Root Cause Analysis ML"

73. Deep Neural Networks for Predicting Physical Properties of Chemical Compounds from Molecular Structure

Domain: Molecular Design **Techniques:** Graph Neural Networks, Property Prediction, QSPR **Data Sources:** Molecular structures, Experimental properties, Databases **IEEE Keywords:** "Property Prediction Molecules", "QSPR Machine Learning"

74. Machine Learning Assisted Optimization of Fermentation Process Parameters for Maximum Biomass Productivity

Domain: Bioprocess Engineering **Techniques:** Optimization Algorithms, Neural Networks, Process Control **Data Sources:** Fermentation data, Biomass measurements, Media composition **IEEE Keywords:** "Fermentation Optimization", "Bioprocess ML"

75. Data-Driven Modeling of Heat Exchanger Performance Degradation Due to Fouling Using Operational Data

Domain: Heat Transfer **Techniques:** Degradation Modeling, Time Series Analysis, Regression **Data Sources:** Temperature profiles, Pressure drop, Fouling measurements **IEEE Keywords:** "Heat Exchanger Fouling", "Performance Degradation ML"

76. Computer Vision for Automated Foam Detection and Characterization in Chemical Reactors and Separation Units

Domain: Process Monitoring **Techniques:** Image Classification, Foam Analysis, Real-time Detection **Data Sources:** Process images, Foam properties, Operating conditions **IEEE Keywords:** "Foam Detection", "Process Vision ML"

77. Machine Learning Framework for Predicting Viscosity of Polymer Solutions as Function of Concentration and Temperature

Domain: Rheology **Techniques:** Regression, Neural Networks, Temperature Dependence Modeling **Data Sources:** Viscosity measurements, Concentration data, Temperature **IEEE Keywords:** "Viscosity Prediction", "Polymer Solution ML"

78. Deep Learning Based Prediction of Critical Micelle Concentration for Surfactant Systems Using Molecular Descriptors

Domain: Surfactant Science **Techniques:** Regression, Deep Learning, Molecular Modeling **Data Sources:** CMC measurements, Molecular structures, Literature data **IEEE Keywords:** "CMC Prediction", "Surfactant ML"

79. Data Mining and Machine Learning for Emission Prediction and Optimization in Combustion Processes

Domain: Combustion Engineering **Techniques:** Regression, Optimization, Multi-objective Modeling **Data Sources:** Combustion parameters, Emission measurements, Fuel data **IEEE Keywords:** "Emission Prediction", "Combustion Optimization ML"

80. Machine Learning Models for Predicting Membrane Flux Decline in Water Treatment Processes Using Fouling Indicators

Domain: Membrane Technology **Techniques:** Time Series Analysis, Regression, Fouling Prediction **Data Sources:** Flux data, Water quality, Operating conditions **IEEE Keywords:** "Membrane Fouling Prediction", "Water Treatment ML"

Category 5: Environmental & Agricultural Engineering (15 Projects)

81. Machine Learning and Remote Sensing for Crop Yield Prediction Using Multi-Temporal Satellite Imagery and Weather Data

Domain: Precision Agriculture **Techniques:** CNN, Time Series Analysis, Multi-modal Learning **Data Sources:** Satellite images, Weather data, Yield records **IEEE Keywords:** "Crop Yield Prediction", "Remote Sensing ML Agriculture"

82. Deep Learning Based Classification of Land Use and Land Cover Changes Using High-Resolution Satellite Imagery

Domain: Environmental Monitoring **Techniques:** Semantic Segmentation, CNN, Change Detection **Data Sources:** Satellite images, Ground truth, LULC maps **IEEE Keywords:** "Land Cover Classification", "Satellite Image ML"

83. Data-Driven Modeling of Air Quality Index Using Traffic Data, Meteorological Variables, and Industrial Emissions

Domain: Air Pollution **Techniques:** Regression, Time Series Forecasting, Feature Engineering **Data Sources:** Air quality monitors, Traffic counts, Weather data **IEEE Keywords:** "Air Quality Prediction", "Pollution Modeling ML"

84. Machine Learning Framework for Predicting Irrigation Water Requirements Based on Soil Moisture and Crop ET

Domain: Water Management **Techniques:** Time Series Forecasting, Regression, IoT Integration **Data Sources:** Soil sensors, Weather data, Crop coefficients **IEEE Keywords:** "Irrigation Prediction", "Water Management ML"

85. Convolutional Neural Networks for Automated Detection and Mapping of Deforestation Using Multi-Temporal Imagery

Domain: Forest Monitoring **Techniques:** Change Detection, Image Segmentation, Time Series CNN **Data Sources:** Satellite images, Forest inventory, Deforestation records **IEEE Keywords:** "Deforestation Detection", "Forest Monitoring ML"

86. Data Science Approach to Predicting Groundwater Level Fluctuations Using Rainfall, Temperature, and Extraction Data

Domain: Hydrogeology **Techniques:** Time Series Analysis, LSTM, Multivariate Forecasting **Data Sources:** Groundwater levels, Rainfall, Well extraction **IEEE Keywords:** "Groundwater Level Prediction", "Hydrology ML"

87. Machine Learning and IoT Sensor Networks for Real-Time Detection of Pest Infestation in Agricultural Fields

Domain: Pest Management **Techniques:** Classification, Anomaly Detection, Sensor Fusion **Data Sources:** Trap sensors, Environmental sensors, Pest counts **IEEE Keywords:** "Pest Detection ML", "Smart Agriculture IoT"

88. Deep Learning Based Soil Type Classification from Hyperspectral Remote Sensing Data for Precision Agriculture

Domain: Soil Science **Techniques:** Hyperspectral Analysis, CNN, Classification **Data Sources:** Hyperspectral images, Soil samples, Ground truth **IEEE Keywords:** "Soil Classification Remote Sensing", "Hyperspectral ML"

89. Data-Driven Prediction of Algal Bloom Occurrence in Lakes Using Water Quality Parameters and Climate Data

Domain: Water Quality **Techniques:** Classification, Time Series Analysis, Early Warning **Data Sources:** Water quality data, Algae counts, Climate variables **IEEE Keywords:** "Algal Bloom Prediction", "Water Quality ML"

90. Machine Learning Models for Estimating Biomass and Carbon Stock in Forest Ecosystems from LiDAR Data

Domain: Forest Carbon **Techniques:** Regression, Point Cloud Processing, Feature Extraction **Data Sources:** LiDAR data, Field measurements, Tree inventory **IEEE Keywords:** "Biomass Estimation", "LiDAR Forest ML"

91. Computer Vision and Deep Learning for Automated Weed Detection and Species Classification in Crop Fields

Domain: Weed Management **Techniques:** Object Detection, Classification, Transfer Learning
Data Sources: Field images, Weed annotations, Species database **IEEE Keywords:** "Weed Detection ML", "Crop Field Vision"

92. Data Science Framework for Predicting Drought Severity Using Climate Indices and Remote Sensing Vegetation Data

Domain: Drought Monitoring **Techniques:** Classification, Time Series Analysis, Index Prediction
Data Sources: Climate data, NDVI, Precipitation records **IEEE Keywords:** "Drought Prediction", "Climate ML"

93. Machine Learning Assisted Estimation of Evapotranspiration from Eddy Covariance Data and Meteorological Variables

Domain: Hydroclimatology **Techniques:** Regression, Neural Networks, Gap Filling **Data Sources:** Flux tower data, Weather data, Remote sensing **IEEE Keywords:** "Evapotranspiration Estimation", "Eddy Covariance ML"

94. Deep Learning for Automated Detection of Crop Diseases from Leaf Images Captured by Mobile Devices

Domain: Plant Pathology **Techniques:** Image Classification, Transfer Learning, Mobile Deployment **Data Sources:** Leaf images, Disease labels, Field surveys **IEEE Keywords:** "Crop Disease Detection", "Plant Pathology ML"

95. Data-Driven Optimization of Wastewater Treatment Plant Operations for Energy Efficiency and Effluent Quality

Domain: Water Treatment **Techniques:** Multi-objective Optimization, Neural Networks, Process Control **Data Sources:** WWTP data, Effluent quality, Energy consumption **IEEE Keywords:** "WWTP Optimization", "Wastewater Treatment ML"

Category 6: Materials Science & Metallurgy (10 Projects)

96. Machine Learning Enabled Prediction of Mechanical Properties of Steels from Chemical Composition and Heat Treatment

Domain: Ferrous Metallurgy **Techniques:** Regression, Neural Networks, Property-Processing Relationships **Data Sources:** Steel composition, Heat treatment, Mechanical tests **IEEE Keywords:** "Steel Property Prediction", "Mechanical Property ML"

97. Deep Learning and Microscopy Image Analysis for Automated Microstructure Classification in Metallic Alloys

Domain: Microstructure Analysis **Techniques:** Image Classification, Segmentation, Transfer Learning **Data Sources:** Microscopy images, Phase identification, Annotations **IEEE Keywords:** "Microstructure Classification", "Metallography ML"

98. Data-Driven Approach to Predicting Phase Transformation Temperatures in Alloy Systems Using Thermodynamic Data

Domain: Physical Metallurgy **Techniques:** Regression, Neural Networks, CALPHAD Integration **Data Sources:** Transformation temperatures, Composition, Cooling rates **IEEE Keywords:** "Phase Transformation Prediction", "Alloy Design ML"

99. Machine Learning Models for Predicting Corrosion Resistance of Metallic Materials in Different Environments

Domain: Corrosion Science **Techniques:** Classification, Regression, Feature Engineering **Data Sources:** Corrosion tests, Material composition, Environment factors **IEEE Keywords:** "Corrosion Resistance Prediction", "Material Durability ML"

100. Convolutional Neural Networks for Automated Crack Detection and Characterization in Metallographic Images

Domain: Failure Analysis **Techniques:** Object Detection, Image Segmentation, Crack Analysis **Data Sources:** Metallographic images, Crack measurements, Failure modes **IEEE Keywords:** "Crack Detection Metallography", "Failure Analysis ML"

101. Deep Learning Based Prediction of Fatigue Strength of Metals from Microstructural Features and Loading Conditions

Domain: Fatigue Behavior **Techniques:** Regression, Deep Learning, Microstructure-Property Links **Data Sources:** Fatigue tests, Microstructure data, Loading history **IEEE Keywords:** "Fatigue Strength Prediction", "Metal Fatigue ML"

102. Data Science Framework for Inverse Design of Alloys with Targeted Properties Using Machine Learning

Domain: Alloy Design **Techniques:** Inverse Design, Genetic Algorithms, Property Optimization **Data Sources:** Alloy databases, Property targets, Composition space **IEEE Keywords:** "Alloy Inverse Design", "Materials Discovery ML"

103. Machine Learning and X-Ray Diffraction Analysis for Phase Identification and Quantification in Complex Materials

Domain: Materials Characterization **Techniques:** Pattern Recognition, Regression, Peak Analysis **Data Sources:** XRD patterns, Phase databases, Quantitative analysis **IEEE Keywords:** "XRD Phase Identification", "Materials Characterization ML"

104. Deep Neural Networks for Predicting Weldability of Advanced High-Strength Steels from Composition and Process Parameters

Domain: Welding Metallurgy **Techniques:** Classification, Neural Networks, Weldability Assessment **Data Sources:** Weld tests, Steel composition, Welding parameters **IEEE Keywords:** "Weldability Prediction", "AHSS Welding ML"

105. Data-Driven Modeling of Recrystallization Kinetics in Cold-Worked Metals Using Thermal and Deformation History

Domain: Thermo-Mechanical Processing **Techniques:** Kinetic Modeling, Regression, Time-Temperature Analysis **Data Sources:** Recrystallization data, Deformation parameters, Annealing **IEEE Keywords:** "Recrystallization Kinetics", "TMP Machine Learning"

Implementation Framework for All Projects

Phase 1: Literature Review & Problem Definition (Week 1-2)

- Search IEEE Xplore, ScienceDirect, Google Scholar
- Find 5-10 relevant research papers
- Identify research gap and project scope
- Define objectives and expected outcomes
- Select appropriate ML techniques

Phase 2: Data Collection & Preparation (Week 3-4)

- Identify data sources (experimental, simulation, public datasets)
- Collect or generate required data
- Data cleaning and preprocessing
- Exploratory Data Analysis (EDA)
- Feature engineering and selection
- Data augmentation if needed
- Train/validation/test split

Phase 3: Model Development & Training (Week 5-8)

- Select baseline models
- Implement ML/DL architectures
- Hyperparameter tuning
- Cross-validation
- Model comparison and selection
- Ensemble methods if applicable
- Performance metrics evaluation

Phase 4: Validation & Testing (Week 9-10)

- Test on unseen data
- Comparison with existing methods
- Statistical significance testing
- Error analysis
- Sensitivity analysis
- Model interpretability (SHAP, LIME)

Phase 5: Application Development (Week 11-12)

- Web interface development (Flask/Streamlit)
- API development
- Dashboard creation
- User interface design
- Deployment (cloud or local)

Phase 6: Documentation & Reporting (Week 13-14)

- Technical report writing
- Research paper draft
- Presentation preparation
- Code documentation
- User manual
- GitHub repository setup

Key Resources for Each Domain

Civil Engineering

Datasets: PEER, DesignSafe-CI, UCI Repository **Software:** ETABS, SAP2000, ANSYS integration **Papers:** ASCE journals, Engineering Structures

Mechanical Engineering

Datasets: NASA Prognostics, PHM Conference datasets **Software:** MATLAB, LabVIEW, Solidworks **Papers:** ASME journals, Mechanical Systems and Signal Processing

Electrical Engineering

Datasets: UCI Power Systems, OpenEI, Physionet **Software:** MATLAB/Simulink, PSCAD, Python **Papers:** IEEE Power & Energy, IEEE Transactions

Chemical Engineering

Datasets: NIST, PubChem, ChemSpider **Software:** Aspen Plus, COMSOL, Python **Papers:** AIChE journals, Chemical Engineering Science

Environmental & Agriculture

Datasets: NASA Earth Data, USDA, FAO, Sentinel Hub **Software:** QGIS, Google Earth Engine, Python **Papers:** Remote Sensing journals, Agricultural Systems

Materials Science

Datasets: Materials Project, AFLOW, NIMS **Software:** CALPHAD, Thermo-Calc, Python **Papers:** Acta Materialia, Materials Science journals

AI Tools for Implementation

For Data Analysis:

- Python (Pandas, NumPy, Scikit-learn)
- MATLAB (Statistics and ML Toolbox)
- R (caret, tidyverse)

For Deep Learning:

- PyTorch, TensorFlow, Keras
- Fast.ai for quick prototyping
- Hugging Face for NLP

For Computer Vision:

- OpenCV, Pillow

- TorchVision, Albumentations
- Detectron2, YOLO

For Signal Processing:

- SciPy, librosa
- PyWavelets for wavelets
- pywt for time-frequency analysis

For Deployment:

- Flask, FastAPI for APIs
- Streamlit for dashboards
- Docker for containerization
- AWS/GCP/Azure for cloud

AI Assistants:

- Claude (code generation, debugging, explanation)
 - GitHub Copilot (code completion)
 - ChatGPT (documentation, research summaries)
 - Cursor AI (full project development)
-

Tips for Success

Start with Strong Foundation

- Read 5-10 papers thoroughly
- Understand domain fundamentals
- Identify state-of-the-art methods

Data is Critical

- Ensure sufficient quality data
- Perform thorough EDA
- Document data sources

Iterative Development

- Start simple, increase complexity
- Validate at each step
- Keep baseline comparisons

✓ Documentation Throughout

- Maintain research notebook
- Document all experiments
- Version control with Git

✓ Focus on Novelty

- Novel application domain
- Novel combination of techniques
- Novel dataset or methodology
- Better performance than existing

✓ Practical Implementation

- Create working demo
- User-friendly interface
- Real-world applicability
- Scalability considerations

Project Report Structure (IEEE Format)

1. **Abstract** - 200-250 words
2. **Introduction** - Problem, motivation, objectives
3. **Literature Review** - Existing methods, research gap
4. **Methodology** - Data, preprocessing, ML models
5. **Results & Discussion** - Performance metrics, comparisons
6. **Conclusion** - Key findings, future work
7. **References** - IEEE format citations

Document Version: 3.0

Created: December 2025

Total Projects: 105 Research-Grade Data Science Projects

All projects combine ML/AI with specific engineering domains

IEEE paper backing available for all project types