SYLLABUS
2026-27

PG DIPLOMA
IN
COMPUTATIONAL DESIGN AND AI IN ARCHITECTURE

DEPARTMENT OF ARCHITECTURE
FACULTY OF ARCHITECTURE & EKISTICS
JAMIA MILLIA ISLAMIA
NEW DELHI-110025

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PG DIPLOMA IN COMPUTATIONAL DESIGN AND AI IN ARCHITECTURE

The PG Diploma in Computational Design and AI in Architecture is a forward-looking, interdisciplinary programme designed for graduates from diverse academic backgrounds who wish to engage with the transformative role of computation and AI in the built environment. As cities, buildings, and infrastructures become increasingly data-driven and intelligent, the demand for professionals who can think algorithmically, analyze data critically, and design responsively is rapidly expanding. This programme introduces foundational concepts in artificial intelligence, machine learning, computational modelling, parametric design, urban analytics, simulation, and smart environments.

Through an integrated model of lectures, computational labs, and design studios, students learn to translate data into spatial insight, develop generative design systems, evaluate building performance, and address ethical and professional questions surrounding AI. Graduates emerge with a robust portfolio showcasing their ability for emerging roles as computational design specialists, AI design consultants, and urban data analysts to perform AI-assisted design practice, sustainability and performance consulting, urban data analytics, smart environments, digital innovation, and interdisciplinary research.

The programme welcomes graduates from all streams who seek to future-proof their careers and become innovators in the rapidly evolving landscape of design and technology.

PG DIPLOMA IN COMPUTATIONAL DESIGN AND AI IN ARCHITECTURE

COURSE STRUCTURE / SCHEME OF EXAMINATION

SEMESTER -I

COURSE CATEGORY	CODE	SUBJECT	CLASSES		MARKS				EXAMS (HRS)	CREDIT
			L	ST	IA	WR	VV	TOTAL		
PC	PGDAI 101	AI & Machine Learning Fundamentals	2	1	40	60	-	100	3	3
PC	PGDAI 102	Computational Foundations & Python	1	2	40	60	-	100	3	3
SEC	PGDAI 103	Computational Design-I	1	2	60	-	40	100	-	3
PC	PGDAI 104	Documentation, Communication, and Ethics	1	2	40	60	-	100	3	3
PC	PGDAI 105	Project Studio-I: Generative Design & AI	1	2	60	-	40	100	-	3
OE	PGDAI 106	Open Electives*								3
TOTAL								**500**		**18**

SEMESTER -II

COURSE CATEGORY	CODE	SUBJECT	CLASSES		MARKS				EXAMS (HRS)	CREDIT
			L	ST	IA	WR	VV	TOTAL		
PC	PGDAI 201	Deep Learning & Generative AI	2	1	40	60	-	100	3	3
PC	PGDAI 202	Computer Vision and Spatial AI	1	2	40	60	-	100	3	3
SEC	PGDAI 203	Computational Design-II	1	2	60	-	40	100	-	3
PC	PGDAI 204	Project Studio-II: Digital Fabrication and Prototyping	1	2	60	-	40	100	-	3
PC	PGDAI 205	Project Studio-III: Smart & Urban Environments	1	2	60	-	40	100	-	3
OE	PGDAI 206	Open Electives*								3
TOTAL								**500**		**18**

**Open Electives:* Elective from various prior approved online portals (SWAYAM, NPTEL, MOOCs) and pool of departmental electives

Code	***Course Category***	***Code***	***Abbreviations***	***Code***	***Abbreviations***
PC	Professional Core	T	Tutorial	WR	Written Exam
PE	Professional Elective	ST	Studio	VV	Viva Voce
SEC	Skill Enhancement Course	IA	Internal Assessment		
OE	Open Elective				

Total Credits = **36**

SEMESTER I

PGDAI 101: AI & Machine Learning Fundamentals

CLASSES / WEEK		MARKS				EXAM HOURS	CREDITS
L	*ST*	*IA*	*WR*	*VV*	*TOTAL*		
2	1	40	60	-	100	3	**3**

Intent

This is an introductory AI/ML course for graduates from any discipline, using architectural, urban and environmental examples. It builds conceptual understanding, basic technical literacy, and critical awareness.

Learning Outcomes

After completing the course, students will be able to:

- Distinguish between different types of AI and identify appropriate applications in the built environment
- Apply descriptive statistics, probability concepts, and visual data reasoning to architectural datasets
- Build, evaluate, and interpret regression and classification models for design performance tasks
- Critically evaluate AI outputs for bias, fairness, explainability, and responsible use in practice

Contents

Unit 1: AI, Data and Intelligent Systems in the Built Environment

- What is AI? Symbolic, statistical, generative, and agentic AI;
- Everyday AI systems: recommenders, chatbots, navigation, building management particulars.
- AI project lifecycle: framing a problem, data, model, evaluation, deployment.
- Limitations of ML; when not to use it; human–AI collaboration principles.
- Introduction to AI ethics and responsibility: bias, fairness, transparency
- Regulatory context: ISO/IEC 42001, EU AI Act overview; India NITI Aayog AI strategy
- Applications of AI in architecture and design

Unit 2: Mathematical and Statistical Foundations

- Numbers, vectors, and matrices through geometry: points, transformations, combinations of variables.
- Descriptive statistics: mean, median, variance, correlation; reading distributions.
- Probability and uncertainty.
- Sampling, bias, representativeness.
- Visual reasoning with small datasets: plots, trends, outliers through KNIME.

Unit 3: Supervised Learning: Regression

- Concept of supervised learning; inputs/outputs, training/validation/test sets.
- Linear and polynomial regression; simple feature engineering.
- Performance prediction: energy use intensity, comfort indices, footfall for spaces.
- Error metrics: MAE, MSE, RMSE, R^2; overfitting and underfitting in intuitive terms.
- Applications of regression in architecture and design

Unit 4: Supervised Learning: Classification

- Classification tasks: risk zoning, occupancy categories, defect detection, image labels.
- Logistic regression, decision trees, k-NN at conceptual level.
- Confusion matrix, precision, recall, F1.
- Bias and fairness: dataset imbalance, sensitive features, impact on housing, credit, policing.
- Applications of supervised learning in architecture and design

Unit 5: Unsupervised Learning and ML-Assisted Design Thinking

- Unsupervised learning: clustering, dimensionality reduction, anomaly detection.
- k-means and hierarchical clustering for neighbourhoods, DBSCAN.
- PCA as "finding axes of variation"; visualizing design or urban option spaces.
- Applications of unsupervised learning in architecture and design

Suggested Readings

1. Russell, S., & Norvig, P. (2020). *Artificial intelligence: A modern approach* (4th ed.). Pearson.

2. Alpaydin, E. (2020). *Introduction to machine learning* (4th ed.). MIT Press.

3. Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep learning*. MIT Press.

4. Géron, A. (2025). *Hands-on machine learning with Scikit-Learn and PyTorch*. O'Reilly Media.

5. Mollick, E. (2024). *Co-intelligence: Living and working with AI*. Portfolio.

6. NITI Aayog. (2021). *Approach document for India: Part 1 — Principles for responsible AI*. Government of India.

PGDAI 102: Computational Foundations & Python

CLASSES / WEEK		MARKS				EXAM HOURS	CREDITS
L	*ST*	*IA*	*WR*	*VV*	*TOTAL*		
1	2	40	60	-	100	3	**3**

Intent

It introduces computational thinking and Python for learners from any discipline, focusing on data handling, simple geometry, and agent-ready tools.

Learning Outcomes

After completing the course, students will be able to:

- Apply computational thinking to decompose design problems into algorithmic procedures and communicate them as flowcharts and pseudo-code
- Write modular, readable, and documented Python scripts using variables, control structures, functions, and standard libraries
- Manipulate and clean datasets using Python data structures, NumPy, and pandas
- Produce publication-quality data visualisations and documented computational notebooks for design and research communication
- Generate parametric 2D geometry in Python and design reusable functions suitable for integration with parametric tools and AI agent systems

Contents

Unit I: Computational Thinking and Algorithmic Design

- Computational thinking: decomposition, pattern recognition, abstraction, algorithms
- 3D geometry: points, vectors, and basic trigonometry
- Everyday algorithms in design and planning
- Flowcharts and pseudo-code: documenting a design decision procedure
- Limits of computation and the role of judgement and ethics.
- Course setup: Python environment

Unit II: Python Programming Fundamentals

- Python syntax: variables, data types, operators, expressions, input/output
- Control structures: conditionals and loops
- Functions: defining, calling, returning values, docstrings
- Errors, debugging, and code readability

Unit III: Data Structures

- Built-in data structures: lists, tuples, dictionaries, sets; when to use which
- Reading and writing data: CSV, JSON, and text files
- Introduction to NumPy: arrays, vectorised operations, coordinate batch processing
- Introduction to pandas: DataFrames, indexing, filtering, grouping, merging
- Data cleaning and transformation for built-environment datasets.

Unit IV: Visualization & EDA

- Basic plotting with Matplotlib and seaborn: line, bar, scatter, histogram
- Storytelling with data: axes, scales, colour, annotations
- Visualising temporal, spatial, and categorical patterns
- Documenting computational workflows: Jupyter markdown cells, narrative structure

Unit V: Computational Geometry and Agentic Tool Design

- Coordinate systems: 2D points, vectors, distances, transformations using NumPy
- Parametric grids and procedural 2D geometry in Python.
- Understanding agents, function calling
- Designing reusable functions as "tools" for AI agents.

Suggested Readings

1. Sweigart, A. (2025). *Automate the boring stuff with Python* (3rd ed.). No Starch Press.

2. Downey, A. (2024). *Think Python: How to think like a computer scientist* (3rd ed.). O'Reilly Media.

3. McKinney, W. (2022). *Python for data analysis* (3rd ed.). O'Reilly Media.

4. VanderPlas, J. (2022). *Python data science handbook* (2nd ed.). O'Reilly Media.

5. Menges, A., & Ahlquist, S. (2011). *Computational design thinking*. Wiley.

6. Peters, B. (2013). Computation works: The building of algorithmic thought. *Architectural Design, 83*(2).

7. Pottmann, H., Asperl, A., Hofer, M., & Kilian, A. (2015). *Architectural geometry* (2nd ed.). Bentley Institute Press.

PGDAI 103: Computational Design-I

CLASSES / WEEK		MARKS				EXAM HOURS	CREDITS
L	*ST*	*IA*	*WR*	*VV*	*TOTAL*		
1	2	60	-	40	100	-	**3**

Intent

It introduces visual programming and parametric design for learners from varied backgrounds, emphasizing rule-based form, data-driven parameters, and documentation.

Learning Outcome

After completing the course, students will be able to:

- Navigate Rhino's interface and construct basic 2D/3D geometry.
- Build parametric models in Grasshopper to generate rule-based architectural form.
- Apply procedural generation techniques to produce complex architectural geometries from simple rules.
- Prepare and execute a digital fabrication workflow from a parametric model to a physical prototype.

Contents

Unit 1: Rhino Fundamentals and Setup

- Interface navigation, viewports, and display modes; construction planes, Gumball, and object snaps for precision modelling
- Basic curve and surface creation: lines, curves, extrude, loft, revolve, sweep, simple architectural massing
- File setup conventions: units, tolerances, layers, naming for parametric and fabrication-ready workflows
- Guided exercise: modelling a simple building massing using these tools

Unit 2: Fundamentals of Parametric and Rule-Based Design

- Parametric vs static modelling; relationships, constraints, control parameters.
- Visual programming concepts: nodes, wires, data flow, data lists/trees
- Rhino/Grasshopper interface fundamentals: component types, canvas organisation, wiring conventions, and data-matching logic
- Basic geometry in a parametric environment: points, curves, surfaces, meshes.
- Patterns and tilings; repetition and variation with control.
- Historical precedents of rule-based and modular design.

Unit 3: Data Structures, Attractors, and Modular Systems

- Data structures in Grasshopper: lists, trees, and branches-grafting, flattening, path mapping, data structure, and geometry outcome
- Number sliders, value remapping, and domain manipulation
- Attractor points and curves: modulating façade opening sizes, panel densities, structural member depths, and surface curvature from a field of influence
- Modular systems: panels, blocks, furniture components, prefabricated assemblies

Unit 4: Procedural Modelling

- Procedural vs parametric- understanding the distinction
- Non-linear data pipelines, feedback loops, and recursive growth geometry using Anemone.
- Surface Tessellation: Automating complex structural framing, diagrids, and multi-pattern surface panelling via Lunchbox.
- Integrated Workflows: Multi-plugin computational pipelines to build unified, automated pipelines.
- Parametric Optimization: Design responsive architectural skins that instantly rebuild and adapt to changing input parameters.

Unit 5: Fabrication and Documentation

- Machine familiarization: Supervised laser cutting session, kerf measurement, tolerance and joint fit tests across MDF, plywood, and acrylic
- Fabrication technology families: Subtractive, additive, and formative processes introduced through physical samples
- File to factory workflow: parametric model→ DXF/STL export→ toolpath→ machine→ assembled component
- Scale conventions: 1:500 to 1:20, each implying different materials, joint resolution, and fabrication process; fabricating a simple element at two scales to understand scale demands.
- Waffle fabrication exercise: Creating a physical waffle model from a Grasshopper-generated form
- Reflective documentation of the design process for portfolio and jury.

Suggested Readings

1. Woodbury, R. (2010). *Elements of parametric design*. Routledge.

2. Kolarevic, B. (2003). *Architecture in the digital age: Design and manufacturing*. Spon Press.

3. Tedeschi, A. (2014). *AAD, algorithms-aided design: Parametric strategies using Grasshopper*. Le Penseur.

4. Burry, M. (2011). *Scripting cultures: Architectural design and programming*. Wiley.

5. Issa, R. (n.d.). *Essential mathematics for computational design* (4th ed.). Robert McNeel & Associates.

6. Issa, R. (n.d.). *Essential algorithms and data structures for Grasshopper*. Robert McNeel & Associates.

7. Jabi, W. (2023). *Parametric design for architecture* (2nd ed.). Laurence King Publishing.

8. Schumacher, P. (2011). *The autopoiesis of architecture: Vol. 1. A new framework for architecture*. Wiley.

PGDAI 104: Documentation, Communication, and Ethics

CLASSES / WEEK		MARKS				EXAM HOURS	CREDITS
L	*ST*	*IA*	*WR*	*VV*	*TOTAL*		
1	2	40	60	-	100	3	**3**

Intent

- To develop hands-on competence in AI usage for documentation, analysis, and communication.
- To build an ethical framework for academic integrity, data privacy, and professional responsibility.

Learning Outcomes

After completing the course, students will be able to:

- Design AI-assisted workflows for architectural research, documentation, and communication.
- Use AI tools to synthesise literature, analyse datasets, and generate professional documentation.
- Understand ethical, legal, and professional implications of AI use in architectural practice.

Contents

Unit I: The AI-Augmented Researcher & Semantic Search

- How LLMs work: text → embeddings → tokens.
- Search in LLMs: Moving from keyword-based search to semantic, conversational search.
- Knowledge Synthesis with AI: working with documents to create a personal, interrogatable knowledge base.
- Literature Reviews: Using AI to cross-reference multiple documents, extract key themes.
- Interrogating the Output: hallucination, reliability, verification, and source credibility.

Unit II: Intelligent Documentation and Drafting

- Prompt Engineering for Professionals: Advanced techniques for framing prompts (role-playing, zero-shot vs. few-shot prompting, constraint setting) for precise outputs.
- Word Processing AI: Automating the drafting of project proposals, client emails, and meeting minutes.
- Tone and Audience: Modulating AI outputs to suit different stakeholders.
- The "Human-in-the-Loop" Editing: Refine, fact-check, and humanize AI-generated text.

Unit III: Data Analysis and Workflows

- Data literacy fundamentals: types of data, sources, and basic statistical concepts.
- AI in Spreadsheets: Using natural language to query data, generate pivot tables, and automate formatting.
- Advanced Data Interpretation: Cleaning messy datasets (e.g., local contractor quotes, environmental survey data).
- Automated Visualization: Using AI to generate charts, graphs, heatmaps, and no-code dashboards to explain data trends clearly.
- Architectural Application: Automating Area Statements, preliminary BOQs, project timeline tracking.

Unit IV: Visual Communication and Pitching

- Automated Slide Generation: Using AI tools to rapidly transform text outlines into presentation.
- Narrative Structuring: Using AI as a brainstorming partner to structure the "arc" of a presentation.
- Graphic Synthesis: Generating bespoke diagrams, workflow charts, and conceptual graphics.
- Contextual Aesthetics: cultural and professional sensibilities in presentations.

Unit V: Ethics, Authorship, and Professional Responsibility

- AI ethics framework: The FATE framework, GDPR, India's DPDP/DPDPR for data-privacy guidance.
- Algorithmic bias: Sources, manifestations, and consequences in design and architecture.
- Intellectual property and Authorship: who owns AI-generated work? Plagiarism in AI-generated work, AI assistance vs academic dishonesty
- Data privacy and surveillance: how AI tools collect and use data, informed consent and professional responsibility, dangers of uploading sensitive information to public LLMs.
- Environmental cost of AI: Energy consumption, carbon footprints, and sustainability implications.
- Global and Indian perspectives in AI governance

Suggested Readings

1. Mollick, E. (2024). *Co-intelligence: Living and working with AI*. Portfolio.

2. Kearns, M., & Roth, A. (2019). *The ethical algorithm: The science of socially aware algorithm design*. Oxford University Press.

3. Eubanks, V. (2018). *Automating inequality: How high-tech tools profile, police, and punish the poor*. St. Martin's Press.

4. Floridi, L., & Cowls, J. (2019). A unified framework of five principles for AI in society. *Harvard Data Science Review, 1*(1).

5. Crawford, K. (2021). *Atlas of AI: Power, politics, and the planetary costs of artificial intelligence*. Yale University Press.

6. Government of India. (2023). *The Digital Personal Data Protection Act, 2023* (No. 22 of 2023).

7. NITI Aayog. (2018). *National strategy for artificial intelligence: #AIforAll*. Government of India.

PGDAI 105: Project Studio- I: Generative Design & AI

CLASSES / WEEK		MARKS				EXAM HOURS	CREDITS
L	*ST*	*IA*	*WR*	*VV*	*TOTAL*		
1	2	60	-	40	100	-	**3**

Intent

The studio integrates computational design, parametric systems, and AI workflows into architectural design exploration. It develops the ability to apply and synthesize digital, analytical, and generative approaches into context-responsive architectural outcomes.

Learning Outcomes

After completing the course, students will be able to:

- Apply computational design, parametric modelling, and AI-assisted workflows within architectural design processes.
- Develop generative and rule-based design proposals using parametric modelling, scripting, and iterative computational exploration.
- Communicate computational workflows and design outcomes through drawings, models, simulations, visualizations, and digital presentations.

Contents:

The studio shall focus on the integration and application of concepts introduced in other subjects, including computational design, AI, parametric modelling, and data-driven architectural processes. Projects shall explore generative and AI-assisted approaches across building, interior, neighbourhood. The studio brief will be formulated as per the current needs, and will be discussed in the studio.

The studio shall examine architectural design as an iterative computational process involving algorithmic thinking, parametric systems, optimization, and AI-supported exploration. Emphasis shall be placed on the relationship between data, geometry, and spatial intelligence in design generation and evaluation.

Studio exercises may include generative form exploration, parametric workflows, AI-assisted visualization using computational and AI-enabled tools.

Final submissions shall include a project report based on documentation of work done, analytical studies, simulations, computational workflows, and design proposals.

SEMESTER II

PGDAI 201: Deep Learning & Generative AI

CLASSES / WEEK		MARKS				EXAM HOURS	CREDITS
L	*ST*	*IA*	*WR*	*VV*	*TOTAL*		
2	1	40	60	-	100	3	**3**

Intent

The course introduces deep learning, generative AI, and agentic AI workflows for architectural design, analysis, and visualization. It develops computational understanding of neural networks, AI-driven generation, and intelligent design systems for architectural applications.

Learning Outcomes

After completing the course, students will be able to:

- Understand core deep learning concepts, neural network architectures, and transfer learning workflows relevant to architectural and urban applications.
- Apply generative AI, diffusion models, and latent-space techniques for architectural image synthesis, spatial exploration, and visual communication.
- Develop AI-assisted workflows integrating classification, generation, retrieval, and evaluation within design and planning contexts.

Contents

Unit I: Neural Networks and Introduction to Deep Learning

- From machine to deep learning: depth, nonlinearity, representation learning
- Architecture of simple feed-forward networks: layers, activation functions, depth vs width
- Training dynamics: gradient descent, backpropagation intuition, epochs, batches, learning rate- KNIME for no-code training
- Conceptual overviews & capabilities: RNN, LSTM, CNN, Transformer
- Graph Neural Networks (GNNs) and Graph Attention Networks (GATs) for layout analysis and programmatic prediction

Unit II: Transfer Learning for Architectural Applications

- Transfer learning concept: why training from scratch is unnecessary; pre-trained models as a foundation; fine-tuning strategies
- Dataset preparation: curation, labelling, augmentation; graded deliverable
- Fine-tuning a pre-trained model; evaluate with precision, recall, F1
- Applications: façade style recognition, heritage damage detection, building element classification
- Model evaluation: accuracy, confusion matrix, visual error analysis

Unit III : Generative Tools for Architecture & Design

- Introduction to GANs: generator and discriminator concept; adversarial training dynamics
- Architectural GAN applications: pix2pix for plan-to-render; CycleGAN for day/night visualisation; StyleGAN for façade style interpolation
- Latent spaces and embeddings
- Explicit comparison of latent space navigation to PCA design option space
- Text-to-3D awareness

Unit IV: Diffusion Tools for Architecture & Design

- Diffusion model intuition: forward diffusion (adding noise) and reverse denoising
- Latent diffusion architectures: pixel-space vs latent-space generation; efficiency vs quality
- ControlNet: guiding generation with architectural inputs; control type: edge map, depth map, segmentation mask.
- Iterative spatial synthesis: img2img, inpainting, outpainting
- Critical evaluation of AI-generated architecture
- Node-based diffusion environment, video-generation models
- Video diffusion models: architectural walkthrough generation

Unit V: Agentic AI

- Designing small AI pipelines: classification → selection → generation → critique
- Embeddings and latent representations for design: using embedding similarity to find precedents; semantic search over a project archive
- Retrieval-Augmented Generation (RAG): concept, architecture; evaluation for accuracy and hallucination
- Agentic AI foundations: stateless vs stateful systems; ReAct framework; tool-enabled agents; perception-action-observation cycles
- Agents vs Skills, multi-level agentic tool system
- Using agents to navigate complex urban frameworks
- ML surrogate models for performance prediction

Suggested Readings

1. Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep learning*. MIT Press.

2. Chollet, F. (2021). *Deep learning with Python* (2nd ed.). Manning.

3. Rombach, R., Blattmann, A., Lorenz, D., Esser, P., & Ommer, B. (2022). High-resolution image synthesis with latent diffusion models. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition* (pp. 10684–10695).

4. Leach, N. (2022). *Architecture in the age of artificial intelligence: An introduction to AI for architects*. Bloomsbury Visual Arts.

5. Crawford, K. (2021). *Atlas of AI: Power, politics, and the planetary costs of artificial intelligence*. Yale University Press.

6. Yao, S., Zhao, J., Yu, D., Du, N., Shafran, I., Narasimhan, K., & Cao, Y. (2023). ReAct: Synergizing reasoning and acting in language models. In *Proceedings of the International Conference on Learning Representations (ICLR)*.

PGDAI 202: Computer Vision and Spatial AI

CLASSES / WEEK		MARKS				EXAM HOURS	CREDITS
L	*ST*	*IA*	*WR*	*VV*	*TOTAL*		
1	2	40	60	-	100	3	**3**

Intent

It introduces computer vision, spatial AI, and remote sensing workflows for analysing, reconstructing, monitoring, and interpreting architectural and urban environments. Students learn to extract spatial meaning from visual data by critically engaging with automated visual systems.

Learning Outcomes

By the end of this subject, students will be able to:

- Understand core computer vision concepts and spatial reconstruction workflows.
- Apply AI-based visual analysis techniques to architectural datasets.
- Critically evaluate the accuracy, ethics, limitations, and societal implications of AI based systems.

Contents

Unit I: Image Fundamentals and Spatial Visual Datasets

- Digital images: pixels, channels, resolution, colour spaces (RGB, grayscale, HSV)
- Python image handling using OpenCV, PIL, NumPy, and AI-assisted coding workflows
- Classical feature extraction as historical context
- Architectural/ urban image datasets: plans, facades, interiors, streetscapes, and satellite imagery
- Satellite image data sources (e.g. ISRO Bhuvan, OpenStreetMap, Mapillary)
- Embeddings for architectural images
- CNN-based classification and its applications.
- Photogrammetry and 3D reconstruction introduction: COLMAP overview

Unit II: Object Detection, Segmentation and Spatial Understanding

- Object detection with YOLO: bounding boxes, confidence thresholds, non-maximum suppression
- Semantic segmentation, Instance segmentation
- Depth estimation from monocular imagery
- Model evaluation metrics: mAP, IoU, mean IoU; interpret confidence scores
- False negative, consequences of model errors in safety and heritage contexts
- Dataset annotation for architectural and urban imagery
- Facade analysis with AI: openings, material recognition, frontage continuity, street-edge analysis

Unit III: Geometric Vision, Photogrammetry and Spatial Reconstruction

- Feature detection, feature matching, homography, panorama stitching, and façade rectification
- Depth estimation, stereo reconstruction, and Structure-from-Motion (SfM) workflows
- Photogrammetry pipelines for buildings, interiors, streets, and heritage documentation
- Drone imagery workflows: UAV surveys, overlap logic, orthophoto generation, aerial mapping
- Point cloud fundamentals and Scan-to-BIM concepts

- Introduction to NeRFs and Gaussian Splatting for immersive spatial capture and representation

Unit IV: Vision AI for Construction Monitoring and Environmental Interpretation

- Construction progress monitoring: image differencing, temporal change detection
- PPE and safety detection: running a pre-trained model; evaluating false positives and negatives
- As-built vs BIM comparison; identifying spatial deviations
- Optical flow and video analysis for activity tracking and spatial monitoring
- Urban Heat Island interpretation using thermal imagery and remote sensing datasets
- Environmental image analysis: vegetation cover, impervious surfaces, shading, waterlogging, flood imagery interpretation
- Ethics of surveillance, automated monitoring, and AI-based visual governance systems

Unit V: Remote Sensing and Urban Spatial Intelligence

- Remote sensing fundamentals: multispectral, thermal, SAR, and hyperspectral urban imagery
- Land Use and Land Cover (LULC) interpretation using AI-assisted satellite image workflows
- Building footprint extraction and environmental feature detection from aerial imagery
- Change detection using multi-temporal satellite imagery: urban expansion and environmental monitoring
- Streetscape analytics: greenery ratio, enclosure index, pedestrian infrastructure quality, public-space assessment
- Crowd density, pedestrian counting, movement interpretation using video feeds and CCTV imagery
- Combining computer vision outputs with GIS workflows in QGIS and GeoPandas environments
- Case studies of architectural workflows in practice e.g. on urban visualizations, digital twins, GAN
- Surveillance, control, and public space freedoms

Suggested Readings

1. Szeliski, R. (2022). *Computer vision: Algorithms and applications* (2nd ed.). Springer.

2. Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep learning*. MIT Press.

3. Kaehler, A., & Bradski, G. (2016). *Learning OpenCV 3: Computer vision in C++ with the OpenCV library*. O'Reilly Media.

4. Prince, S. J. D. (2012). *Computer vision: Models, learning, and inference*. Cambridge University Press.

5. He, K., Zhang, X., Ren, S., & Sun, J. (2016). Deep residual learning for image recognition. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition* (pp. 770–778).

6. Long, J., Shelhamer, E., & Darrell, T. (2015). Fully convolutional networks for semantic segmentation. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition* (pp. 3431–3440).

7. Dosovitskiy, A., et al. (2021). An image is worth 16x16 words: Transformers for image recognition at scale. In *Proceedings of the International Conference on Learning Representations (ICLR)*.

8. Mildenhall, B., et al. (2020). NeRF: Representing scenes as neural radiance fields for view synthesis. In *Proceedings of the European Conference on Computer Vision (ECCV)*.

9. Biljecki, F., & Ito, K. (2021). Street view imagery in urban analytics and GIS: A review. *Landscape and Urban Planning, 215*, 104217.

11. Zuboff, S. (2019). *The age of surveillance capitalism: The fight for a human future at the new frontier of power*. PublicAffairs.

13. National Remote Sensing Centre, ISRO. (n.d.). *Bhuvan: Indian geo-platform of ISRO* [geoportal].

PGDAI 203: Computational Design-II

CLASSES / WEEK		MARKS				EXAM HOURS	CREDITS
L	*ST*	*IA*	*WR*	*VV*	*TOTAL*		
1	2	60	-	40	100	-	**3**

Intent

The course develops the ability to integrate climate, structure, material behaviour, and parametric systems into responsive and performance-informed architecture.

Learning Outcomes

After completing the course, students will be able to:

- Analyse environmental, daylight, thermal, and wind performance parameters using computational simulation workflows for diverse architectural contexts.
- Develop performance-driven parametric and physics-based design systems integrating environmental, structural, and material behaviour.
- Apply evolutionary optimisation techniques to evaluate and improve architectural performance.

Contents

Unit I: Environmental Analysis Foundations

- Sun path geometry: solar angles, altitude, azimuth, and the logic of the sun path diagram
- Weather data: reading and interpreting EPW files
- Shadow casting and solar access analysis: sun hours, shadow range studies, overshadowing
- Solar radiation analysis: cumulative radiation mapping on facades and roofs; identifying high-gain and low-gain zones for shading and aperture design decisions
- Wind rose interpretation and prevailing wind direction for site-specific design
- Microclimate considerations

Unit II: Performance-Driven Parametric Design

- Daylight simulation using the Radiance engine using Honeybee; setting up sensor grids, sky models, and material properties
- Key daylight metrics: Spatial Daylight Autonomy (SDA), Annual Sunlight Exposure (ASE), Useful Daylight Illuminance (UDI)
- Glare analysis: Daylight Glare Probability (DGP) for critical view points
- Thermal performance concepts: heat gain coefficients, U-values, thermal mass
- Using simulation outputs (radiation values, daylight factors, shadow hours) as numerical inputs to automate shading and envelope design.
- Case studies: performance-integrated parametric facades and envelopes

Unit III: Computational Form-Finding and Physics-Based Design

- Fundamentals of structural behaviour in architectural systems using Karamba3D and Grasshopper.
- Exploration of minimal surfaces, catenary curves, biomimetic systems and naturally optimised geometries through Kangaroo Physics simulations.
- Behavioural modelling concepts including particle systems, springs, constraints, dynamic relaxation, equilibrium and force-based simulations within parametric workflows.
- Development of tensile membranes, cable-net structures, shell forms and force-responsive architectural systems using Kangaroo, Weaverbird and LunchBox.

Unit IV: BIM Integration and Intelligent Building Systems

- Rhino.Inside.Revit/BIM integration: live-linking Grasshopper to Revit, parameter round-tripping, exporting parametric outputs for documentation and coordination
- Data-driven design decisions: feasibility, massing, area calculations for stakeholder communication
- Intelligent Building Systems: sensor networks, Building Automation Systems (BAS), and IoT fundamentals (occupancy, temperature, CO2, lux) for real-time building performance monitoring
- Digital twins: linking live sensor data to parametric/BIM models, recalibrating previous simulations against actual performance data
- AI-driven building management: predictive HVAC, lighting and shading control from occupancy and environmental data patterns; feeding monitored data into Galapagos/Octopus fitness functions

Unit V: Evolutionary Optimization

- Single-objective optimisation with Galapagos: fitness functions, genome sliders, evolutionary solver vs simulated annealing
- Multi-objective optimisation with Octopus: Pareto front analysis, navigating trade-offs between competing metrics simultaneously
- Interpreting Pareto results: what the frontier means, how to select a design from a non-dominated set, and the limits of algorithm-driven decision-making
- Using Ladybug/Honeybee simulation metrics directly as Galapagos or Octopus fitness functions

Suggested Readings

1. Szokolay, S. V. (2014). *Introduction to architectural science: The basis of sustainable design* (3rd ed.). Routledge.
2. Frazer, J. (1995). *An evolutionary architecture*. Architectural Association Publications.
3. Hensel, M., & Menges, A. (2006). *Morpho-ecologies*. Architectural Association Publications.
4. Hensen, J. L. M., & Lamberts, R. (Eds.). (2019). *Building performance simulation for design and operation* (2nd ed.). Routledge.
5. Reinhart, C. (2014, 2018). *Daylighting handbook I & II*. Building Technology Press.
6. Bureau of Energy Efficiency. (n.d.). *ECBC code user guide* (current version). Government of India.
7. GRIHA Council & The Energy and Resources Institute. (2019). *GRIHA V.2019, Volume 1: Introduction to the national rating system*. TERI Press.
8. Krishan, A., Baker, N., Yannas, S., & Szokolay, S. V. (Eds.). (2001). *Climate responsive architecture: A design handbook for energy efficient buildings*. Tata McGraw-Hill.

PGDAI 204: Project Studio- II: Digital Fabrication and Prototyping

CLASSES / WEEK		MARKS				EXAM HOURS	CREDITS
L	*ST*	*IA*	*WR*	*VV*	*TOTAL*		
1	2	60	-	40	100	-	**3**

Intent

This course is a fabrication studio in which students use their existing projects done in previous semester to move from material behaviour and computational testing to a final prototype.

Learning Outcomes

After completing the course, students will be able to:

- Demonstrate material understanding, and simulating material behaviour before fabrication.
- Prepare parametric and AI-generated geometry for machine-ready production, resolving fabricability, joint design, tolerancing, and nesting.
- Critically engage with robotic fabrication, AI-to-fabrication pipelines, and ethics of automation.

Contents

SECTION A

Unit I: Fabrication-Ready Geometry, Site Models, and Data Translation

- Diagnosing fabricability: Non-manifold geometry, unsupported overhangs, weak joints, and unprintable wall thicknesses
- Site model fabrication workflows using GIS contours, photogrammetry, Python, and Grasshopper
- Parametric tolerancing and joint systems: press-fit, clearance-fit, offsets, and shrinkage control; parametric joint families.
- Documentation: Cutting layouts, part numbering, assembly diagrams, exploded axonometrics
- Deepnest or Grasshopper-based packing logic for material efficiency; cost and waste differences between optimised and unoptimized nesting.

Unit II: Precision 2D Fabrication: Laser Cutting, CNC Routing, and Material Programming

- Laser cutting: Multi-pass cutting, engraving, surface articulation across MDF, plywood, and acrylic; parametric kerf bending patterns
- CNC routing: Toolpath strategies, fixturing, tool selection, depth-of-cut management; shallow relief milling.
- Fabrication drawing: Complete cutting layouts-part numbers, material call-outs, scale bar, assembly sequence notes
- AI-optimised and manual nesting related to real sheet costs and material waste; calculating cost difference between optimized and unoptimized nesting
- Craft, post-processing, and finishing: Sanding, edge treatment, and hand-finishing.

Unit III: Additive Manufacturing, Casting, and Full Prototype Build

- 3D printing in depth and DfAM: FDM, SLA, and SLS; resolution, performance, and cost;

- Moulding/ casting using laser-cut, CNC: Sheet-derived moulds for casting plaster, concrete, resin
- Scan-to-fabricate: Phone-based photogrammetry and point-cloud processing workflows for converting captured building or site conditions into fabricatable geometry.
- Hybrid fabrication and structural logic: Combining laser-cut sheets, 3D-printed nodes, and cast panels with structural validation through Karamba before assembly.
- Assembly sequencing: Preparation of numbered part sets, exploded axonometrics, and assembly sequence drawings prior to fabrication.
- Overview of Robotic Fabrication, AI Pipelines, and Critical Futures

SECTION B

Fabrication Project

In this semester, students are supposed to take up fabrication of their existing projects to understand practical application of different processes of fabrication, and develop their final prototypes.

Suggested Readings

1. Iwamoto, L. (2009). *Digital fabrications: Architectural and material techniques*. Princeton Architectural Press.

2. Kolarevic, B. (2003). *Architecture in the digital age: Design and manufacturing*. Spon Press.

3. Gramazio, F., & Kohler, M. (2014). *The robotic touch: How robots change architecture*. Park Books.

5. Fu, J., Zong, X., & Yuan, P. F. (Eds.). (2026). *AI for Architecture: Proceedings of the 5th International Conference on Computational Design (CCD 2024)*. Springer. https://doi.org/10.1007/978-981-95-0974-4

6. Gershenfeld, N. (2005). *Fab: The coming revolution on your desktop—from personal computers to personal fabrication*. Basic Books.

7. Karamba3D and Kangaroo Physics. (n.d.). *Documentation*.

8. Deepnest, RhinoCAM, Ultimaker Cura, and Grasshopper Waffle Plugin. (n.d.). *Documentation*.

9. McKinsey Global Institute. (2017). *A future that works: Automation, employment, and productivity*. McKinsey & Company.

PGDAI 205: Project Studio- III: Smart & Urban Environments

CLASSES / WEEK		MARKS				EXAM HOURS	CREDITS
L	*ST*	*IA*	*WR*	*VV*	*TOTAL*		
1	2	60	-	40	100	-	**3**

Intent

The studio integrates AI, spatial intelligence, environmental simulation, and digital fabrication into architectural and urban design workflows. It develops the ability to create intelligent, performance-driven, and data-informed design solutions through computational and AI-assisted methods.

Learning Outcomes

Upon successful completion of the course, students shall be able to:

- Integrate AI, computer vision, simulation, and fabrication workflows within design processes.
- Develop generative, performance-responsive, and data-informed design proposals using computational and AI-assisted methods.
- Communicate AI-driven design processes and outcomes through simulations, visualizations, prototypes, datasets, and integrated design presentations.

Contents:

The studio shall focus on the integration and application of concepts learnt including deep learning, generative AI, computer vision, environmental simulation, optimization, and digital fabrication. Projects shall investigate intelligent and performance-responsive approaches to architecture, interiors, urbanism, and environmental systems through computational and AI-assisted workflows.

Studio exercises may be undertaken in sync with the assignments in PGDAI 202 and PGDAI 203, and may include AI-assisted spatial analysis, computer vision-based interpretation, generative image and form synthesis, simulation-informed optimization, parametric systems, photogrammetry, spatial reconstruction, fabrication-informed geometries, and AI-enabled decision-support systems using contemporary computational tools and workflows.

The studio may include individual and collaborative projects, urban intelligence studies, and interdisciplinary explorations addressing contemporary architectural and urban challenges.

Students may choose from three verticals for developing their final project:

- Urban AI / spatial analytics track- Computer vision + mapping/ unsupervised learning + urban insight
- Performance design track- Climate analysis + parametric optimization
- AI + fabrication track- Generative system + prototype

Final submissions will be in the form of a project report which shall include documentation of work done e.g. analytical studies, simulations, computational workflows, fabrication, and design proposals.

Suggested Readings

1. Batty, M. (2013). *The new science of cities*. MIT Press.
2. Ministry of Housing and Urban Affairs. (2015). *Smart Cities Mission: Statement and guidelines*. Government of India.