Training Course on Unsupervised Learning and Clustering (Advanced)

Professional Development Training Course Outline

Category	Data Science	**Duration**	10 Days
Base Fee	$3,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

This intensive training course offers a comprehensive exploration of **advanced unsupervised learning** techniques, equipping participants with the expertise to extract profound insights from complex, unlabeled datasets. Focusing on **cutting-edge clustering algorithms**, **robust anomaly detection methodologies**, and **powerful dimensionality reduction strategies**, this program goes beyond foundational concepts, delving into the practical implementation and nuanced application of these critical **machine learning** domains. Participants will gain hands-on experience with real-world **case studies**, fostering a deep understanding of how to unlock hidden patterns, identify outliers, and simplify high-dimensional data in diverse industry scenarios.

Training Course on Unsupervised Learning & Clustering (Advanced) is meticulously designed to empower data professionals with the skills to tackle challenging problems where traditional supervised approaches fall short. By mastering **deep clustering**, **density-based clustering**, **manifold learning**, and advanced **outlier detection**, attendees will be able to build highly effective **unsupervised models** for **customer segmentation**, **fraud detection**, **predictive maintenance**, and **exploratory data analysis**. This course emphasizes a practical, project-based learning approach, ensuring that participants not only grasp the theoretical underpinnings but also develop the proficiency to deploy and interpret sophisticated **unsupervised learning solutions** in real-world business environments.

Programme Curriculum

Training Course on Unsupervised Learning & Clustering (Advanced): Deep Dives into Advanced Clustering, Anomaly Detection, and Dimensionality Reduction

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Course Objectives

1. Gain proficiency in spectral clustering, DBSCAN, Gaussian Mixture Models (GMMs), and hierarchical clustering for diverse data structures.
2. Understand and apply autoencoder-based clustering and neural network-driven clustering for learning rich data representations.
3. Develop expertise in Isolation Forest, One-Class SVM, and time-series anomaly detection for identifying critical outliers.
4. Apply and compare PCA, t-SNE, UMAP, and Non-Negative Matrix Factorization (NMF) for data visualization and feature engineering.
5. Learn to critically evaluate and interpret the results of clustering and dimensionality reduction models for actionable insights.
6. Acquire strategies for pre-processing and analyzing big data with numerous features using unsupervised methods.
7. Design and implement scalable machine learning architectures for processing large, unlabeled datasets efficiently.
8. Gain hands-on experience with popular Python libraries like scikit-learn, TensorFlow, and PyTorch for unsupervised tasks.
9. Work through practical case studies spanning customer segmentation, cybersecurity, healthcare analytics, and manufacturing.
10. Understand hyperparameter tuning and evaluation metrics specific to unsupervised learning.
11. Discuss bias detection and fairness in unsupervised learning models and their societal impact.
12. Create compelling projects demonstrating mastery of advanced unsupervised techniques.
13. Explore emerging research and future directions in unsupervised deep learning and generative AI.

Organizational Benefits

- Uncover hidden patterns and relationships within vast, unlabeled datasets, leading to novel business insights and opportunities.
- Drive data-driven strategies by segmenting customers, identifying fraudulent activities, and predicting equipment failures with greater accuracy.

- Streamline operations by automating data categorization, reducing manual effort in data exploration and preparation.
- Leverage advanced AI capabilities to develop innovative products, personalize services, and gain a deeper understanding of market dynamics.
- Proactively detect anomalies and outliers, enhancing security, preventing fraud, and ensuring operational stability.
- Reduce data complexity and improve the performance of downstream machine learning models through effective dimensionality reduction.
- Identify inefficiencies and potential issues early through predictive maintenance and anomaly detection, minimizing downtime and unexpected expenses.
- Empower data scientists and analysts with specialized skills in the rapidly evolving field of unsupervised machine learning.

Target Audience

1. Data Scientists.
2. Machine Learning Engineers.
3. AI Developers.
4. Data Analysts
5. Researchers.
6. Business Intelligence Professionals.
7. Software Engineers.
8. Anyone with foundational ML knowledge

Course Outline

Module 1: Unsupervised Learning Foundations (Recap & Advanced Perspectives)

- Revisiting core concepts: Differences between supervised, unsupervised, and semi-supervised learning.
- The role of unsupervised learning in **generative AI** and **representation learning**.
- Challenges and opportunities with **unlabeled data** in modern AI landscapes.
- Evaluation metrics unique to unsupervised learning (e.g., Silhouette score, Davies-Bouldin index).
- **Case Study:** Understanding the strategic advantage of unsupervised learning for a startup with limited labeled data.

Module 2: Advanced K-Means & Initialization Strategies

- K-Means variants: K-medoids, Mini-Batch K-Means.
- Intelligent initialization techniques: K-Means++, GMM-based initialization.
- Determining optimal 'k': Elbow method, Silhouette analysis, Gap statistic.
- Handling categorical data with K-Modes and K-Prototypes.
- **Case Study:** Optimizing website content recommendation by dynamically clustering user behavior with advanced K-Means.

Module 3: Hierarchical & Density-Based Clustering

- Agglomerative vs. Divisive hierarchical clustering: Linkage methods (Ward, Complete, Average).
- Dendrogram interpretation and practical application.
- **DBSCAN**: Understanding epsilon and min_samples for noise reduction.
- **OPTICS** for handling varying density clusters.

- **Case Study:** Identifying geological fault lines from seismic data using hierarchical and DBSCAN clustering.

Module 4: Gaussian Mixture Models (GMMs) & Expectation-Maximization (EM)

- Probabilistic clustering with GMMs: Modeling data as a mixture of Gaussian distributions.
- The **Expectation-Maximization (EM)** algorithm for GMM parameter estimation.
- Determining optimal number of components for GMMs (AIC, BIC).
- Applications in soft clustering and density estimation.
- **Case Study:** Segmenting customer demographics for targeted marketing campaigns using GMMs, allowing for overlapping segments.

Module 5: Spectral Clustering & Graph-Based Methods

- Graph representation of data: Similarity graphs and adjacency matrices.
- Fundamentals of **spectral graph theory** and eigenvalues.
- Implementing spectral clustering for non-linearly separable data.
- Challenges and solutions in constructing similarity graphs.
- **Case Study:** Community detection in social networks or identifying tightly knit groups in collaborative platforms.

Module 6: Advanced Anomaly Detection: Statistical & Proximity-Based

- Review of statistical methods: Z-score, IQR, Gaussian distribution-based.
- **Local Outlier Factor (LOF)**: Detecting anomalies based on local density deviations.
- **K-Nearest Neighbors (K-NN) for Outlier Detection**.
- Choosing appropriate thresholds and evaluation metrics for anomaly detection.
- **Case Study:** Detecting unusual network traffic patterns indicating potential cyber intrusions.

Module 7: Advanced Anomaly Detection: Tree-Based & Deep Learning

- **Isolation Forest**: Building decision trees to isolate anomalies.
- **One-Class SVM**: Learning a boundary around normal data points.
- Introduction to **Autoencoders for Anomaly Detection**: Reconstructing normal data, flagging high reconstruction errors.
- Time-series specific anomaly detection techniques (e.g., Seasonal-Trend decomposition using Loess - STL).
- **Case Study:** Proactive identification of equipment malfunctions in manufacturing through sensor data anomaly detection.

Module 8: Principal Component Analysis (PCA) & Feature Selection

- In-depth review of **PCA**: Eigenvectors, eigenvalues, variance explained.
- Interpreting principal components and scree plots.
- Dimensionality reduction for visualization and noise reduction.
- Feature selection vs. Feature extraction: When to use each.
- **Case Study:** Reducing dimensionality of gene expression data to identify key genes contributing to disease.

Module 9: Manifold Learning: t-SNE & UMAP

- Introduction to **manifold learning** concepts: Preserving local and global structures.
- **t-Distributed Stochastic Neighbor Embedding (t-SNE)** for visualizing high-dimensional data.

- **Uniform Manifold Approximation and Projection (UMAP)**: Faster and more scalable alternative to t-SNE.
- Hyperparameter tuning for t-SNE and UMAP for optimal visualization.
- **Case Study:** Visualizing high-dimensional customer purchasing patterns to discover latent customer segments.

Module 10: Non-Negative Matrix Factorization (NMF) & Topic Modeling

- Fundamentals of **NMF**: Decomposing matrices into non-negative components.
- Applications in **topic modeling** and feature extraction.
- Interpreting NMF components and their significance.
- Sparsity constraints and their impact on NMF results.
- **Case Study:** Extracting hidden topics from large document collections (e.g., customer reviews, news articles).

Module 11: Unsupervised Learning in Natural Language Processing (NLP)

- Word embeddings (Word2Vec, GloVe) for unsupervised text representation.
- Clustering text documents or sentences based on semantic similarity.
- **Latent Dirichlet Allocation (LDA)** for probabilistic topic modeling.
- Unsupervised methods for text summarization and keyword extraction.
- **Case Study:** Automatic categorization of customer feedback or support tickets for sentiment analysis and issue routing.

Module 12: Unsupervised Learning in Computer Vision

- Clustering image features (e.g., SIFT, SURF) for image recognition.
- Unsupervised learning for image segmentation and object detection pre-training.
- Autoencoders for image denoising and anomaly detection in visual data.
- Generative Adversarial Networks (GANs) as an advanced unsupervised technique (conceptual overview).
- **Case Study:** Unsupervised grouping of similar images in large datasets for content organization or anomaly detection in medical imaging.

Module 13: Scalability and Performance Optimization

- Strategies for handling **big data** with unsupervised learning algorithms.
- Parallel and distributed computing for clustering and dimensionality reduction.
- In-memory processing and out-of-core algorithms.
- Optimizing code for speed and memory efficiency in Python.
- **Case Study:** Implementing scalable clustering on a large-scale e-commerce dataset for real-time customer segmentation.

Module 14: Unsupervised Learning Model Deployment & Monitoring

- Packaging and deploying unsupervised models into production environments.
- Monitoring model performance and concept drift in unsupervised settings.
- Retraining strategies for unsupervised models.
- Interpreting and presenting unsupervised findings to non-technical stakeholders.
- **Case Study:** Deploying an anomaly detection system for fraud in financial transactions and setting up real-time alerts.

Module 15: Ethical AI, Bias & Future Trends in Unsupervised Learning

- Addressing potential biases in unsupervised learning models and data.

- Fairness and transparency in clustering and anomaly detection.
- Emerging trends: **Self-supervised learning**, **contrastive learning**, **foundation models**.
- The role of unsupervised learning in **Responsible AI**.
- **Case Study:** Analyzing potential biases in customer segmentation outputs and devising mitigation strategies.

Training Methodology

This course adopts a highly interactive and practical training methodology, combining theoretical lectures with extensive hands-on exercises and real-world case studies.

- **Interactive Lectures:** Engaging presentations covering core concepts, algorithms, and advanced techniques.
- **Live Coding Sessions:** Demonstrations and guided coding exercises using Python with libraries like scikit-learn, NumPy, Pandas, Matplotlib, Seaborn, TensorFlow, and PyTorch.
- **Hands-on Labs & Projects:** Practical assignments and a capstone project to apply learned concepts to diverse datasets.
- **Case Study Analysis:** In-depth discussions of real-world industry applications and challenges.
- **Group Discussions & Problem Solving:** Collaborative learning to explore different approaches to complex problems.
- **Q&A Sessions:** Dedicated time for addressing participant queries and fostering deeper understanding.
- **Best Practices & Industry Insights:** Sharing practical tips, common pitfalls, and emerging trends in unsupervised learning.

Register as a group from 3 participants for a Discount

Send us an email: info@fineskilltrainingcenter.org or call *+254769199797*

Certification

Upon successful completion of this training, participants will be issued with a globally- recognized certificate.

Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000
23 Nov 2026	04 Dec 2026	Physical	$3,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$6,000

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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