DATA MINING
ENEX 435

Lecture : 3 **Year : IV**
Tutorial : 2 **Part : I**
Practical : 1

Course Objectives:
The objective of this course is to provide students with a comprehensive understanding of data mining principles and techniques, from input representation and basic algorithms to advanced machine learning schemes and evaluation metrics. Furthermore, it aims to equip students with practical skills in data preprocessing, classification, clustering, and association rule mining using modern analytics tools to address real-world data challenges.

1 Introduction (6 hours)

1.1 Relationship between Data Mining and Machine Learning
1.2 Describing structural patterns using examples: The Weather Problem, Contact Lenses, Irises, CPU Performance, and Labor Negotiations.
1.3 Fielded applications and the distinction between machine learning and statistics
1.4 Ethics in data mining: Reidentification and personal information

2 Input: Concepts, Instances, and Attributes (4 hours)

2.1 Defining concepts, instances, and attributes
2.2 Relational data and the process of denormalization
2.3 Preparing input: ARFF format, attribute types (nominal, ordinal, interval, ratio), and missing/inaccurate values

3 Output: Knowledge Representation (4 hours)

3.1 Representing knowledge as tables and linear models
3.2 Decision trees and various types of rules (classification, association, rules with exceptions)
3.3 Instance-based and cluster representations

4 Algorithms: The Basic Methods (8 hours)

4.1 Inferring rudimentary rules (1R algorithm) and statistical modeling (Naive Bayes)
4.2 Divide-and-conquer: Constructing decision trees (ID3) and calculating Information Gain

4.3 Covering algorithms: Constructing classification rules (PRISM)
4.4 Mining association rules: Item sets and the Apriori algorithm
4.5 Linear models: Linear/Logistic regression, the Perceptron
4.6 Instance-based learning (k-nearest-neighbor) and Clustering (k-means)

5 Credibility: Evaluating What's Been Learned (5 hours)

5.1 Training and testing: Error rate, resubstitution error, and cross-validation
5.2 Comparing data mining schemes and predicting probabilities
5.3 Counting the cost: Cost-sensitive classification, lift charts, and ROC curves
5.4 Evaluating numeric prediction and the Minimum Description Length (MDL) principle

6 Implementations: Real Machine Learning Schemes (10 hours)

6.1 Advanced Decision Trees: C4.5, numeric attributes, and pruning
6.2 Classification Rules: RIPPER algorithm and partial decision trees
6.3 Extending Linear Models: Support Vector Machines (SVM), Multilayer Perceptrons (Neural Nets)
6.4 Advanced Clustering: Hierarchical clustering, incremental clustering (Cobweb)

7 Data Transformations (5 hours)

7.1 Attribute selection: Filter vs. wrapper methods
7.2 Discretization: Unsupervised vs. entropy-based supervised discretization
7.3 Projections: Principal Components Analysis (PCA) and random projections
7.4 Sampling and data cleansing: Handling outliers and one-class learning

8 Moving On: Applications and Beyond (3 hours)

8.1 Learning from massive datasets and data streams
8.2 Foundations of Text Mining and Web Mining

Tutorial (30 hours)

1. Exploratory Data Analysis: Tracing patterns in the Weather and Iris datasets.
2. Input Formatting: Converting raw data into ARFF and handling missing values.
3. Basic Probability: Numerical exercises on Naive Bayes and the Laplace estimator.
4. Decision Tree Math: Calculating entropy and information gain for multi-way splits.
5. Rule Induction Exercises: Manual execution of the PRISM algorithm on small datasets.
6. Association Rule Metrics: Calculating support, confidence, lift, and leverage for item sets.

7. Evaluation Statistics: Constructing confusion matrices, calculating Kappa statistics, and plotting ROC curves.
8. Linear Model Computation: Solving simple weight updates for the Perceptron and Winnow algorithms.
9. Pruning Logic: Tracing subtree replacement and subtree raising.

Practical **(15 hours)**

1. Data Preprocessing: Using filters for normalization and standardization.
2. Classification Basics: Running J48 and Naive Bayes on the weather data.
3. Regression: Using M5' for numeric prediction on CPU performance data.
4. Knowledge Flow: Designing a configuration for streamed data processing.
5. Experimenter: Comparing multiple classifiers (J48, OneR, ZeroR) using 10-fold cross-validation.
6. Association Rules: Mining supermarket data using the Apriori algorithm.
7. Clustering: Applying SimpleKMeans and EM algorithms to the Iris dataset.
8. Attribute Selection: Running CfsSubsetEval and Ranker search.
9. Advanced Classification: Training Multilayer Perceptrons and SVMs (SMO).
10. Ensemble Methods: Implementing Bagging and AdaBoost using metalearners.
11. Text Mining: Using the StringToWordVector filter for document classification.
12. Data Stream Analysis: Using the Moa-related tools for online learning.

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Mark distribution*
1	6	7
2	4	7
3	4	7
4	8	10
5	5	7
6	10	10
7	5	6
8	3	6
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Aggarwal, C. C. (2015). Data mining: The textbook. Springer.
2. Han, J., Kamber, M., & Pei, J. (2011). Data mining: Concepts and techniques (Latest ed.). Morgan Kaufmann.

3. Hastie, T., Tibshirani, R., & Friedman, J. (2009). The elements of statistical learning: Data mining, inference, and prediction (Latest ed.). Springer.
4. Tan, P.-N., Steinbach, M., Karpatne, A., & Kumar, V. (2019). Introduction to data mining (Latest ed.). Pearson.
5. Zaki, M. J., & Meira, W., Jr. (2020). Data mining and machine learning: Fundamental concepts and algorithms (Latest ed.). Cambridge University Press.

IT-BASED INNOVATION AND ENTREPRENEURSHIP
ENEX 436

Lecture : 3 **Year: IV**
Tutorial : 2 **Part : I**
Practical: 1

Course Objectives:

The objective of this course is to develop an entrepreneurial mindset and equip students with the knowledge and skills required to identify, evaluate, develop, and commercialize technology-based business opportunities. Upon completion of the course, students will be able to identify technology-driven opportunities, develop innovative solutions, evaluate business models, build minimum viable products, and formulate technology-based business plans relevant to local and global markets, including the context of Nepal.

1. Entrepreneurship and Entrepreneurial Mindset (6 hours)

1.1 Entrepreneurship vs. Businessman
1.2 Concept, characteristics and importance of entrepreneurship
1.3 Entrepreneurial mindset and entrepreneurial thinking
1.4 Entrepreneurial mindset vs. conventional business mindset
1.5 Opportunity-oriented and problem-oriented thinking
1.6 Effectuation principles
1.7 Role of creativity, risk-taking and experimentation in entrepreneurship

2. Problem Identification and Opportunity Discovery (6 hours)

2.1 Problem identification as the foundation of innovation
2.2 Problem identification techniques
2.3 Customer needs and pain points
2.4 Identifying unmet and emerging customer needs
2.5 Problem validation and problem-solution fit
2.6 Customer observation, interviews and surveys
2.7 Market gaps and technology-based opportunities
2.8 AI for Entrepreneurship
2.9 Technology-based entrepreneurial opportunities
2.10 Case studies of technology-driven startups

3. Technological Innovation and Entrepreneurship (7 hours)

3.1 Concept of technological innovation
3.2 Technological innovation and entrepreneurship
3.3 Types of innovation (Product, Process, Services)
3.4 Technology commercialization
3.5 Technology readiness and commercialization process

3.6 From research and technology to marketable products
3.7 Technology transfer and licensing
3.8 Innovation and business opportunities
3.9 Manual vs. automation technology
3.10 Automation as an entrepreneurial opportunity
3.11 Identifying opportunities for digital transformation
3.12 Case studies of successful technology commercialization

4. Business Models and Competitive Advantages (9 hours)

4.1 Business Model and value creation
4.2 Business Model Canvas (BMC)
4.3 Developing and evaluating a technology-based business model
4.4 Intellectual Property Rights (IPR) Patent, Copyright, Trademark
4.5 Intellectual property protection for IT products and services
4.6 Technology entrepreneurship and competitive advantage
4.7 Sources of competitive advantage
4.8 Sustainable competitive advantage in technology businesses
4.9 Technology, innovation and barriers to entry

5. Lean Startup, Design Thinking and Product Development (7 hours)

5.1 Lean Startup methodology
5.2 Build–Measure–Learn cycle
5.3 Hypothesis-driven entrepreneurship
5.4 Design Thinking
5.5 Customer discovery and validation
5.6 Minimum Viable Product (MVP)
5.7 MVP development strategies for IT products
5.8 Prototype development and user testing
5.9 Product-market fit
5.10 Iterative product development
5.11 Pivoting and experimentation
5.12 Technology adoption and scalability

6. Business Planning and Emerging Technologies (6 hours)

6.1 Business Plan
6.2 Components of a technology-based business plan
6.3 Emerging Technologies and Entrepreneurship
6.4 Emerging IT/Computing technologies
6.5 Emerging technologies as sources of entrepreneurial opportunities
6.6 Technology disruption
6.7 Technology adoption and scalability
6.8 Evaluating the entrepreneurial potential of emerging technologies

7. Technology Entrepreneurship in Nepal (4 hours)

7.1 Employment impact of technology

7.2 Technology and the future of work
7.3 Social impact of technology
7.4 Technology for social entrepreneurship and inclusive development
7.5 Ethical and technical challenges of emerging technologies
7.6 Technology disruption and societal transformation
7.7 Technology entrepreneurship ecosystem in Nepal
7.8 Opportunities and challenges for IT startups in Nepal
7.9 Nepalese technology startups and innovation case studies
7.10 Government, academia, incubators and private-sector support for technology entrepreneurship
7.11 Future prospects of technology entrepreneurship in Nepal

Tutorial **(30 hours)**

1. Entrepreneurial Mindset and Principles: Differentiate between an entrepreneur and a traditional businessman, evaluating the core mindsets and five principles of effectuation in tech startups through real-world case studies.
2. Problem Identification and Customer Analysis: Identify real-world problems and conduct field research using interviews, observations, and surveys: to create detailed customer personas and map pain points.
3. AI-Driven Opportunity and Trend Analysis: Apply AI tools and analyze emerging IT trends to identify tech-based venture opportunities while evaluating the possibilities and limits of Generative AI.
4. Design Thinking and Ideation: Apply the Design Thinking framework to brainstorm, prototype, and refine user-centered solutions for identified real-world challenges.
5. Business Model Canvas Development: Construct and evaluate a full Business Model Canvas (BMC) for a selected technology venture, detailing value propositions and key operations.
6. Process Automation and Strategy: Compare manual and automated business processes to identify efficiency opportunities, while analyzing innovation and commercialization strategies of successful tech startups.
7. Lean Startup and MVP Validation: Apply the Lean Startup Build-Measure-Learn cycle to design, test, and evaluate a Minimum Viable Product (MVP) concept alongside its scalability strategy.
8. Business Planning and IP Management: Draft a preliminary business plan for a tech venture, incorporating patent, copyright, and trademark requirements for IT products and services.
9. Emerging Tech and Industry Impact: Evaluate the entrepreneurial potential, social/employment impacts, and ethical-technical challenges of technologies like AI, IoT, blockchain, and quantum computing.
10. Market Disruption and Local Context: Analyze competitive advantage and tech disruption through industry case studies, focusing specifically on the opportunities and challenges of technology entrepreneurship in Nepal, culminating in a venture proposal presentation.

Practical **(15 hours)**

1. Problem and Opportunity Identification: Document five real-world problems that can be addressed using information technology.
2. Customer Discovery and Persona Development: Conduct customer interviews or surveys to construct customer personas and prepare a pain-point report.
3. Generative AI for Ideation: Use large language models to generate, refine and evaluate technology business ideas while critically assessing the output.
4. Design Thinking and MVP Prototyping: Apply Design Thinking methodology to define problem statements and build a basic minimum viable product using appropriate tools and platforms.
5. Lean Startup Experimentation: Formulate hypotheses, define validation metrics and execute a Build-Measure-Learn cycle for product testing.
6. IP Protection and Process Automation: Map relevant patents, copyrights and trademarks for an IT product while designing an automated solution for a manual business process.
7. Venture Business Plan: Draft a comprehensive business plan covering market, operational, technological and financial components.
8. Nepalese Startup Case Analysis: Analyze a local technology startup to evaluate its business model, market strategy, competitive advantage and scalability.
9. Mini Project Execution and Presentation: Design and present a complete IT-based venture proposal integrating customer validation, business model canvas, minimum viable product and commercialization strategy.

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	6	8
2	6	9
3	7	9
4	9	12
5	7	9
6	6	8
7	4	5
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References:

1. Drucker, P. F. (2006). Innovation and Entrepreneurship. Harper Business.

2. Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Business.
3. Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. John Wiley & Sons.
4. Blank, S., & Dorf, B. (2012). The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company. K&S Ranch.
5. Brown, T. (2009). Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation. Harper Business.
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8. Tidd, J., & Bessant, J. (2020). Managing Innovation: Integrating Technological, Market and Organizational Change. Wiley.
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10. Sarasvathy, S. D. (2008). Effectuation: Elements of Entrepreneurial Expertise. Edward Elgar Publishing.
11. World Intellectual Property Organization. Intellectual Property for Business. WIPO.
12. Blank, S. (2013). Why the Lean Start-Up Changes Everything. Harvard Business Review.

REMOTE SENSING AND GEOSPATIAL DATA PROCESSING
ENEX 437

Lecture : 3 **Year : IV**
Tutorial : 2 **Part : I**
Practical : 1

Course Objectives
The objective of this course is to provide students with a rigorous foundation in the physical principles, electromagnetic wave propagation, and sensor technologies underlying active and passive remote sensing. It further provides an integrated understanding of ground-based, airborne, and spaceborne remote sensing (RS) systems and their applications in geospatial data processing and environmental monitoring.

1. Physical Principles and Data Acquisition (7 Hours)

1.1. Electromagnetic Radiation: Maxwell's wave formulation, electromagnetic energy and energy quantization, solar irradiance, blackbody radiation, Planck's law, Stefan-Boltzmann law, and Wien's displacement law

1.2. Atmospheric Propagation and Windows: Atmospheric absorption and transmission; absorption bands associated with O_2, H_2O, CO_2, and other atmospheric constituents; scattering mechanisms including Rayleigh, Mie, and non-selective scattering; atmospheric transmission windows

1.3. Spectral Signatures: Specular and diffuse reflection, Bidirectional Reflectance Distribution Function (BRDF), and characteristic spectral reflectance curves of vegetation, soils, water, and built structures

1.4. Sensor Electronics and Architectures: Optical sensor payloads, focal-plane arrays, CCD and CMOS sensors, and scanning architectures including pushbroom and whiskbroom systems

1.5. System Resolutions and Trade-offs: Spatial, spectral, radiometric, and temporal resolution; bit depth and signal-to-noise ratio (SNR); trade-offs among different types of resolution; overview of modern Earth-observation constellations including Landsat 8/9, Sentinel-2, and commercial small-satellite systems

2. Active Remote Sensing and Explorations (12 Hours)

2.1. Principles of Microwave Remote Sensing: Microwave interaction with surfaces; dielectric properties, polarization, incidence angle, penetration depth, and surface roughness

2.2. Basic Radar Range Equations, Parameters, Systems and Indicators: Radar equation, range and resolution, pulse duration, pulse repetition frequency (PRF), antenna gain, wavelength, bandwidth, and SNR

2.3. Platforms, Applications and Classifications

2.3.1. Subsurface Exploration using Ground Penetrating Radar (GPR): GPR principles, wave propagation, depth of penetration, reflection and refraction, A-scan and B-scan profiles, and subsurface applications

2.3.2. Ground Surveillance Radars: Principles, target detection and tracking, range and bearing measurement, and surveillance applications

2.3.3. Air Traffic Control (ATC) Radars: Primary and secondary surveillance radar, target detection and tracking, and range, azimuth, and altitude measurement

2.3.4. Moving Target Indicator (MTI) Radar: Doppler effect, clutter suppression, moving-target detection, and blind-speed concepts
2.3.5. Weather Radars: Radar reflectivity, Doppler velocity, precipitation estimation, and weather monitoring applications
2.3.6. Synthetic Aperture Radar (SAR): SAR imaging principles, range and azimuth resolution, radar backscatter, polarization, speckle, geometric distortions, and applications in terrain mapping and environmental monitoring

2.4. LiDAR Systems: LiDAR principles, time-of-flight measurement, point-cloud generation, Digital Elevation Models (DEMs), Digital Surface Models (DSMs), and terrain and environmental applications

3. Passive Remote Sensing (6 Hours)

3.1. Radiometry, Spectrometry and Hyperspectral Sensing: Fundamentals of radiometry, radiant energy, flux, intensity, irradiance, and radiance; spectral radiance and reflectance measurements. Field spectroradiometers and spectral reflectance library integration; principles of optical dispersion; transition from panchromatic to multispectral, superspectral, and contiguous hyperspectral sensing

3.2. Radiometric Calibration: Digital Numbers (DN), sensor calibration, conversion of DN to Top-of-Atmosphere (TOA) radiance and reflectance, and radiometric normalization

3.3. Atmospheric Correction: Empirical Methods: Dark Object Subtraction (DOS), Flat Field correction, and Internal Average Relative Reflectance (IARR). Radiative Transfer Models: Principles of atmospheric radiative transfer, introduction to the 6S model, and operational atmospheric correction using Sen2Cor

3.4. Geometric Restoration and Resampling: Systematic and non-systematic geometric errors, Ground Control Points (GCPs), image registration, polynomial transformation and orthorectification, and interpolation methods including Nearest Neighbor, Bilinear, and Cubic Convolution

3.5. Visual Image Interpretation: Elements of image interpretation including tone, color, texture, pattern, shape, shadow, site, and association; True-Color Composites (TCC) and False-Color Composites (FCC)

4. Digital RS Image Processing and Enhancements (6 Hours)

4.1. Spatial Enhancement and Filtering: Digital image representation, convolution kernels, low-pass smoothing, high-pass sharpening, gradient operators, and edge-detection techniques including Sobel, Prewitt, and Laplacian operators

4.2. Spectral Transformations and Indices: Mathematical formulation and applications of NDVI, NDWI, NBR, and NDRE; Principal Component Analysis (PCA) for band decorrelation; and Tasseled Cap transformation

4.3. Imaging Spectrometry: Multispectral versus hyperspectral remote sensing, hyperspectral data cube representation, spectral sampling, spectral resolution, and Full Width at Half Maximum (FWHM)

4.4. High-Dimensional Data Processing: Curse of dimensionality, Hughes phenomenon, noise reduction, and Minimum Noise Fraction (MNF) transformation

4.5. Spectral Matching and Sub-pixel Unmixing: Spectral Angle Mapper (SAM), Spectral Information Divergence (SID), linear spectral mixture models, endmember extraction, N-FINDR, and Pixel Purity Index

5. RS Pattern Recognition and Classifications (7 Hours)

5.1. Traditional Statistical Classifiers: Unsupervised Classification: K-Means clustering and ISODATA. Supervised Classification: Minimum Distance, Parallelepiped, and Gaussian Maximum Likelihood classifiers

5.2. Machine Learning in Earth Observation: Decision Trees, Random Forest (RF), Support Vector Machines (SVM), feature selection, training and validation datasets, and Object-Based Image Analysis (OBIA) and segmentation

5.3. Overview of Deep Learning and GeoAI: Fundamentals of deep learning for Earth observation, Convolutional Neural Networks (CNNs) for image and scene classification, U-Net architectures for semantic pixel-level segmentation, and introductory applications of deep learning in remote sensing

5.4. Accuracy Assessment and Error Metrics: Confusion/error matrix, Overall Accuracy, Producer's Accuracy, User's Accuracy, precision, recall, F1-score, Kappa coefficient, spatial cross-validation, and sampling strategies for accuracy assessment

6. Chapter 6: Remote Sensing for GIS, Spatial Data Modeling and Environmental Management (7 Hours)

6.1. Spatial Data Modeling in GIS: Vector and raster data structures, coordinate reference systems, geographic and projected coordinate systems, UTM and WGS84, map projections, spatial indexing using R-tree concepts, and raster map algebra

6.2. Modern Geospatial Architectures: Cloud-Optimized GeoTIFFs (COGs), SpatioTemporal Asset Catalogs (STAC), multidimensional geospatial arrays, and array processing using Python libraries including rasterio, geopandas, and xarray

6.3. Environmental Management Applications: Multi-temporal Land-Use/Land-Cover Monitoring: LULC dynamics, post-classification change detection, image differencing, change matrices, and environmental monitoring. Disaster Assessment: Radar backscatter thresholding for flood inundation mapping, pre- and post-event analysis, Normalized Burn Ratio (NBR), and wildfire burn-severity assessment. Thermal Remote Sensing: Thermal infrared remote sensing, Land Surface Temperature (LST), split-window algorithms, and urban heat-island analysis

Tutorial (30 Hours)

1. Radiometric Calculations: Solid angles, spectral radiance, Planck's blackbody equation, Stefan-Boltzmann law, and Wien's displacement law.
2. Orbital and Sensor Geometry: Orbital velocity, ground swath coverage, Ground Sampling Distance (GSD), Field of View (FOV), and Instantaneous Field of View (IFOV).
3. Radar and SAR Calculations: Range and azimuth resolution derivations, SAR geometry problems, layover and foreshortening limits, and radar-equation power budgets.
4. GPR Calculations: Wave velocity in dielectric media, skin depth, attenuation constants, and hyperbolic target localization.
5. Geometric Correction: Polynomial transformation matrices, geometric correction, and mathematical derivation of bilinear and cubic resampling kernels.

6. PCA and Spectral Unmixing: Covariance matrix construction, eigenvalue/eigenvector computation for PCA, and linear spectral unmixing using least-squares inversion.
7. Classification and Accuracy Assessment: Bayesian decision boundaries for Maximum Likelihood Classification, confusion matrix evaluation, and Kappa-statistic calculation.
8. GIS Algorithms: Vector overlay algorithms, raster topology, and computational aspects of map algebra.

Practical **(15 Hours)**

1. Inspecting metadata, reading multi-band imagery in GeoTIFF/HDF5/NetCDF formats, rendering TCC and FCC Composites, and extracting pixel spectral profiles.
2. GCP collection, affine and polynomial transformation, image warping, image-to-image registration, and resampling.
3. Applying custom convolution kernels, Sobel edge detection, high-pass filtering, NDVI and NDWI computation, and PCA.
4. Loading imaging spectrometer data such as AVIRIS, PRISMA, or Hyperion; dimensionality reduction using PCA/MNF; and material mapping using SAM.
5. Multi-temporal change detection using LULC post-classification comparison or differential NDVI/NBR, followed by integration into a GIS-based map layout for environmental interpretation.

Final Exam:

The final examination shall cover all six chapters of the syllabus. The marks are distributed approximately in proportion to the lecture hours.

Chapter	Hours	Marks distribution*
1	7	9
2	12	16
3	6	8
4	6	8
5	7	10
6	7	9
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Adhikari, N. B., & Sharma, S. (2023). Outlook of remote sensing. Shree Chandeshwori Publications.
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