WORKING WEEK 2025 AND Locate25 THE NATIONAL GEOSPATIAL CONFERENCE

FIG Geospatial Council of Australia

Collaboration, Innovation and Resilience: Championing a Digital Generation

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Review of automatic processing of topography and surface feature identification LiDAR data using machine learning techniques

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Introduction

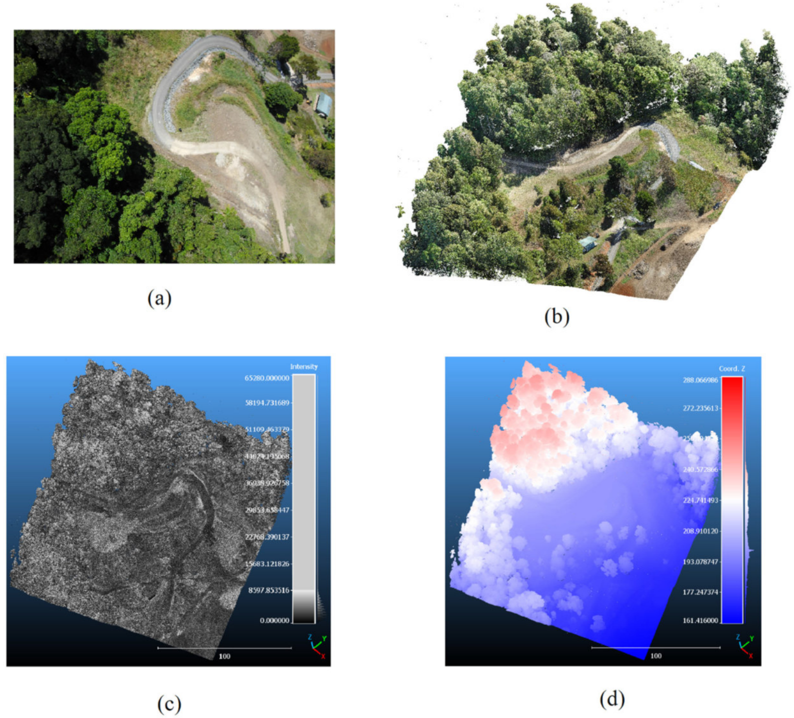
Types of Point Cloud Inputs and Their ML Applications

Automatic Processing Types :

- Automatic Classification :Categorize features (terrain, buildings, etc
- Automatic Modelling: Apply geometry-specific strategies per class

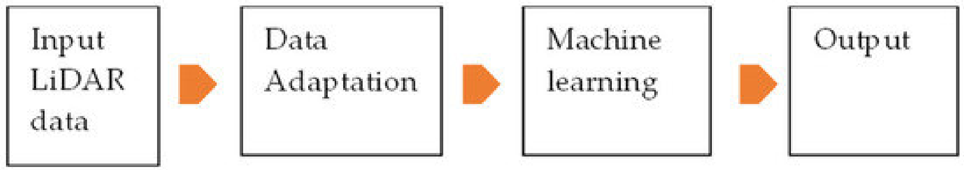
ML Techniques Used

- Supervised: Needs labeled data (e.g., RF, SVM, CNN)
- Unsupervised: No labels required (e.g., k-Means, GANs)



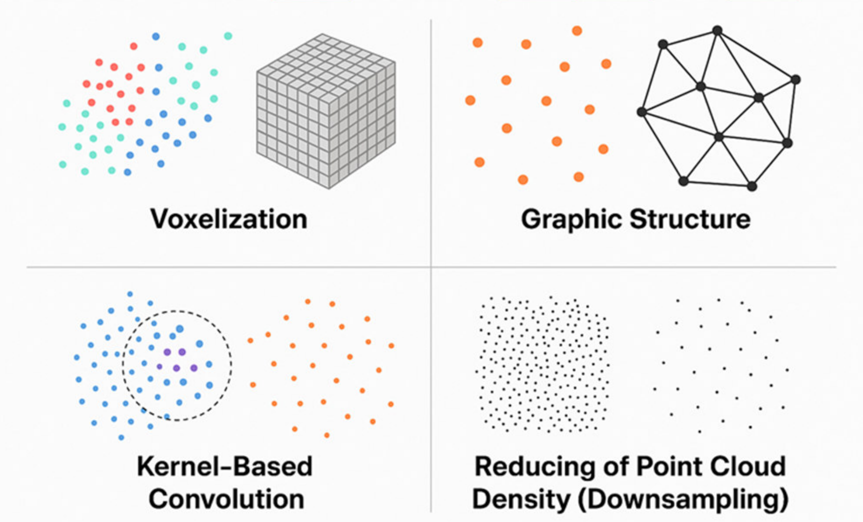
(a) Aerial image of scanned scene; (b–d) 3D LiDAR point cloud visualization (b) using RGB colors; (c) using laser intensity values; (d) using Z coordinate values.

Structuring LiDAR Point Clouds for ML



- ML-based LiDAR processing involves two main stages:
  - **Data Adaptation** (voxelization, graphic, etc.)
  - **ML Algorithm Application**
- Adaptation ensures compatibility with ML frameworks (e.g., converting to 2D/3D matrices)

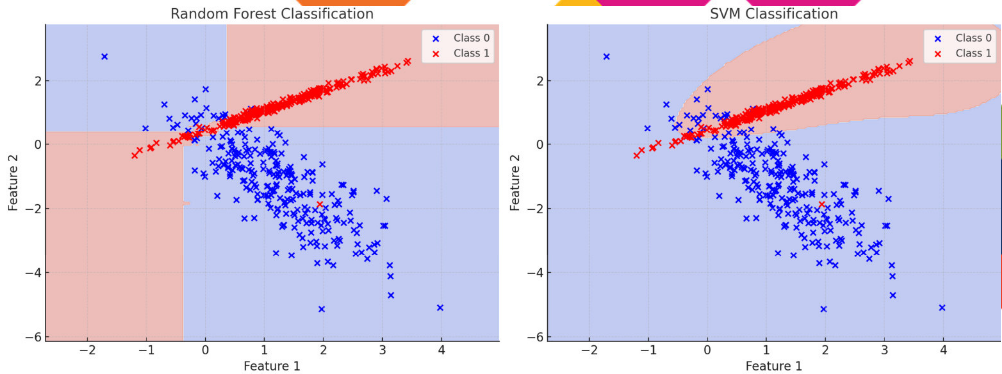
1. **Point Features (per point):** Height above ground, Intensity, Number of returns; Normal vectors, Roughness, ERC (Echo Ratio Coefficient)
2. **Neighbourhood Features:** Local elevation percentiles, planarity, linearity (from eigenvalues)
3. **Aggregated Features** (per grid/voxel):Mean height, point count, std. dev., etc.



Concepts of Point Cloud Structure for Applying ML Algorithms

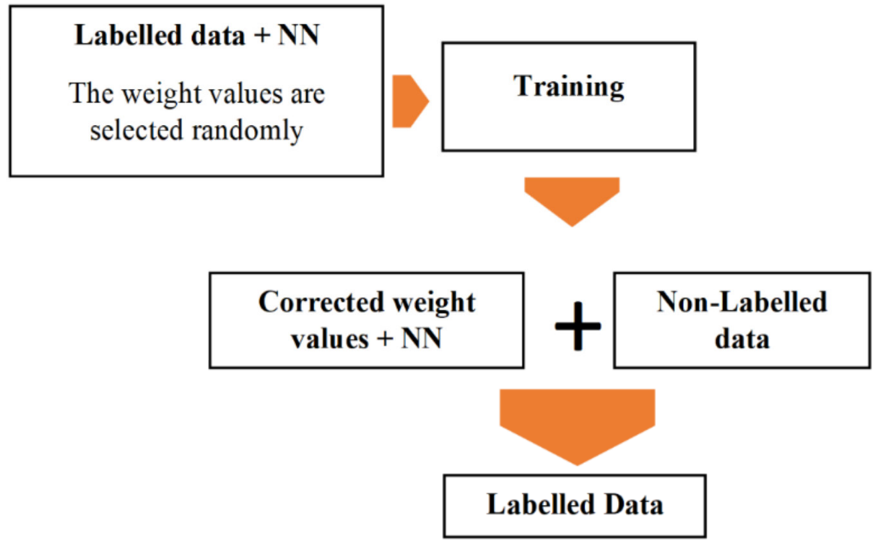
Traditional Machine Learning Methods

- ML aids in classifying large LiDAR datasets
- Two main types: **Supervised** (RF, SVM) and **Unsupervised** (k-means, PCA), **Semi-supervised**
- **Random Forest (RF)**:
  - Widely used for vegetation, building, and terrain classification, High accuracy (e.g., 99% for urban vegetation)
- **Support Vector Machine (SVM)**:
  - Effective for small datasets and nonlinear boundaries Applied in powerline, tree species, and object detection task



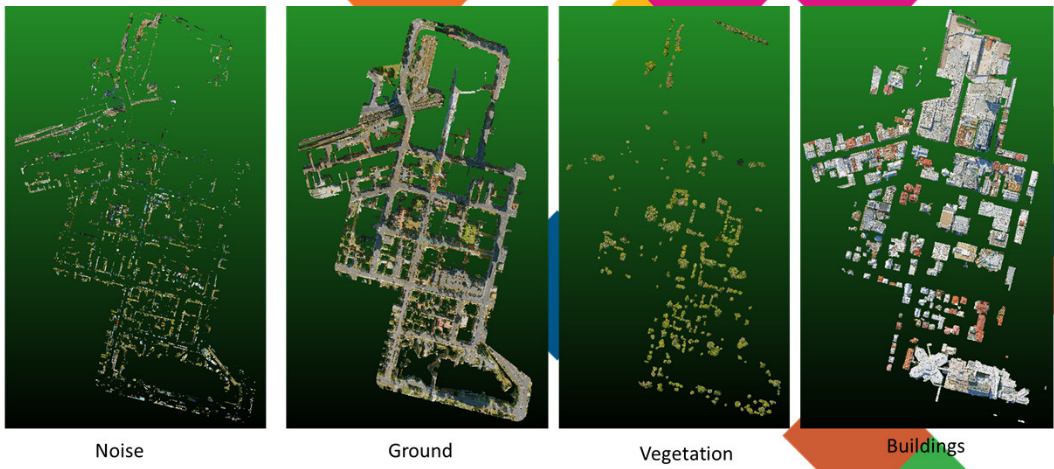
Deep Learning Applications in LiDAR

- **Neural Networks**: Learn patterns from labelled point features
- **PointNet++, KPConv, SparseCNN**: Popular deep models for point clouds
- **Encoder–Decoder Networks**:
  - Extract and reconstruct spatial features
  - Used in segmentation and classification



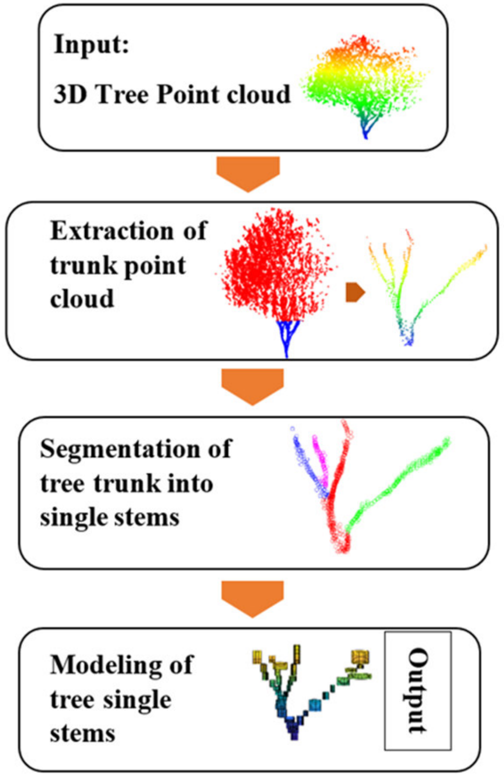
Common ML Applications in LiDAR Data Processing

- **Building Detection**: CNNs, U-Net, PointNet++ for classifying LiDAR + imagery
- **Scene Segmentation**: Up to 9 class types (e.g., roads, shrubs, roofs)
- **Vegetation Classification**:
  - ML used for separating vegetation and non-vegetation
  - Biomass estimation and forest inventory
- **Tree Species Recognition**:
  - Uses voxelization, CNN, RF, SVM
  - Multispectral data boosts species accuracy



ML Applications in LiDAR Data Processing

- **Other Applications**:
  - Powerline detection
  - Road marking classifications
  - Self-driving car scene understanding
- **Research Opportunities**:
  - Unsupervised learning for less labelled data
  - Preserving 3D geometry and reducing data loss are critical research directions
  - ML optimisation for large-scale mapping



The most relevant SDGs related to the presentation and theme of this session

1st relevant SDG: 11 SUSTAINABLE CITIES AND COMMUNITIES

2nd relevant SDG: 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

3rd relevant SDG: 13 CLIMATE ACTION

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Thank you!

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